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ORCID logo ORCID: <https://orcid.org/0000-0002-4358-5411> (2017) RISC-KIT synthesis report.  
Project Report. Risc-kit project. . [Monograph]

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# RISC-KIT

## **Resilience-Increasing Strategies for Coasts – Toolkit**

[www.risckit.eu](http://www.risckit.eu)

## Synthesis Report

Deliverable No: D.4.4 – Synthesis Report

Ref.: WP4 - Task 4.4

Date: 12 April 2017

Deliverable Title	D.4.4 – Synthesis Report
Filename	RISCKIT_D.4.4_Synthesis_Report.3
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Date	April 2017

Prepared under contract from the European Commission

Grant Agreement No. 603458

Directorate-General for Research & Innovation (DG Research), Collaborative project,  
FP7-ENV-2013-two-stage

Start of the project: 01/11/2013

Duration: 42 months

Project coordinator: Stichting Deltares, NL

#### Dissemination level

<input checked="" type="checkbox"/>	PU	Public
<input type="checkbox"/>	PP	Restricted to other programme participants (including the Commission Services)
<input type="checkbox"/>	RE	Restricted to a group specified by the consortium (including the Commission Services)
<input type="checkbox"/>	CO	Confidential, only for members of the consortium (including the Commission Services)

## Deliverable status version control

Version	Date	Author	Review
1.0	10/03/2017	Katriona, McGlade (Ecologic)	Karina Barquet (SEI) Paolo Ciavola (CFR) Ap van Dongeren (Deltares) Oscar Ferreira (UniAlgarve) Ruth Higgins (Eurocean) Grit Martinez (Ecologic) Robert McCall (Deltares) Christophe Viavatenne (FHRC)
2.0	20/03/2017	Katriona, McGlade (Ecologic)	Karina Barquet (SEI) Paolo Ciavola (CFR) Ap van Dongeren (Deltares) Oscar Ferreira (UniAlgarve) Ruth Higgins (Eurocean) Grit Martinez (Ecologic) Robert McCall (Deltares) Christophe Viavatenne (FHRC)
3.0	27/03/2017	Katriona, McGlade (Ecologic)	Ap van Dongeren (Deltares) Grit Martinez (Ecologic) Oscar Ferreira (UniAlgarve) Ruth Higgins (Eurocean) Robert McCall (Deltares) Christophe Viavatenne (FHRC) Paolo Ciavola (CFR)

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## Executive Publishable Summary

Recent and historic low-frequency, high-impact events such as Xynthia (impacting France in 2010), the 2011 Liguria (Italy) Flash Floods and the 1953 North Sea storm surge which inundated parts of the Netherlands, Belgium and the UK have demonstrated the flood risks faced by exposed coastal areas in Europe. Typhoons in Asia (such as Typhoon Haiyan in the Philippines in November 2013), hurricanes in the Caribbean and Gulf of Mexico, and Superstorm Sandy, impacting the north-eastern U.S.A. in October 2012, have demonstrated how even larger flooding events pose a significant risk and can devastate and immobilise large cities and countries.

These coastal zone risks are likely to increase in the future (IPPC, AR5) which requires a re-evaluation of coastal disaster risk reduction (DRR) strategies and a new mix of prevention (e.g. dike protection), mitigation (e.g. limiting construction in flood-prone areas; eco-system based solutions) and preparedness (e.g. Early Warning Systems, EWS) (PMP) measures.

In response to these challenges, the RISC-KIT project has delivered a set of open-source and open-access methods, tools and management approaches to reduce risk and increase resilience to low-frequency, high-impact hydro-meteorological events in the coastal zone (the “RISC-toolKIT”). These products enhance forecasting, prediction and early warning capabilities, improve the assessment of long-term coastal risk and optimise the mix of PMP-measures.

This Synthesis Report provides an overview of the achievements, lessons learned and challenges identified through the RISC-KIT project activities, including the development and application of the tools at ten case study sites in a range of coastal regions across Europe. The lessons learned are then fed into a series of recommendations for improved DRR for Europe and beyond. The resulting insights and accompanying recommendations have been considered in relation to their relevance to EU and international processes that both directly and indirectly address coastal DRR. In particular the insights are considered for their relevance to the EU Floods Directive (2007/60 EC) (FD) and the UNISDR Sendai Framework 2015-2020. In this way, the report addresses the multi-level governance of risk, aligning insights and needs expressed at the local level with macro-level policy goals and highlighting synergies with other policy processes.

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# 1 Introduction

Recent and historic low-frequency, high-impact events such as Xynthia (impacting France in 2010), the 2011 Liguria (Italy) Flash Floods and the 1953 North Sea storm surge which inundated parts of the Netherlands, Belgium and the UK have demonstrated the flood risks faced by exposed coastal areas in Europe. Typhoons in Asia (such as Typhoon Haiyan in the Philippines in November 2013), hurricanes in the Caribbean and Gulf of Mexico, and Superstorm Sandy, impacting the north-eastern U.S.A. in October 2012, have demonstrated how even larger flooding events pose a significant risk and can devastate and immobilise large cities and countries.

These coastal zone risks are likely to increase in the future (IPPC, AR5) which requires a re-evaluation of coastal disaster risk reduction (DRR) strategies and a new mix of prevention (e.g. dike protection), mitigation (e.g. limiting construction in flood-prone areas; eco-system based solutions) and preparedness (e.g. Early Warning Systems, EWS) (PMP) measures. Even without a change in risk due to climate or socio-economic changes, a re-evaluation is necessary in the light of a growing appreciation of ecological and natural values which drive ecosystem-based or Nature-based flood defence approaches. In addition, as free space is becoming sparse, coastal DRR plans need to be spatially efficient, allowing for multi-functionality.

## 1.1 Project objectives

In response to these challenges, the RISC-KIT project aims to deliver a set of open-source and open-access methods, tools and management approaches to reduce risk and increase resilience to low-frequency, high-impact hydro-meteorological events in the coastal zone. These products will enhance forecasting, prediction and early warning capabilities, improve the assessment of long-term coastal risk and optimise the mix of PMP-measures. Specific objectives are:

1. Review and analysis of current-practice coastal risk management plans and lessons-learned of historical large-scale events;
2. Collection of local socio-cultural-economic and physical data at case study sites through end-user and stakeholder consultation to be stored in an impact-oriented coastal risk database;
3. Development of a regional-scale coastal risk assessment framework (CRAF) to assess present and future risk due to multi-hazards (Figure 1.1, top panel);
4. Development of an impact-oriented Early Warning and Decision Support System (EWS/DSS) for hot spot areas consisting of: i) a free-ware system to predict hazard intensities using coupled hydro-meteo and morphological models and ii) a Bayesian-based Decision Support System which integrates hazards and socio-economic, cultural and environmental consequences (Figure 1.1, centre panel);
5. Development of potential DRR measures and the design of ecosystem-based and cost-effective, (non-)technological DRR plans in close cooperation with end-users for a diverse set of case study sites on all European regional seas and on one tropical coast (Figure 1.1; bottom panel);
6. Application of CRAF and EWS/DSS tools at the case study sites to test the DRR plans for a combination of scenarios of climate-related hazard and socio-economic vulnerability change and demonstration of the operational mode;



- 
7. Development of a web-based management guide for developing integrated DRR plans along Europe's coasts and beyond and provide a synthesis of lessons learned in RISC-KIT in the form of policy guidance and recommendations at the national and EU level.

The tools are to be demonstrated on case study sites on a range of EU coasts in the North- and Baltic Sea Region, Atlantic Ocean, Black Sea and Mediterranean Sea, and one site in Bangladesh, see Figure 1.2. These sites constitute diverse geomorphic settings, land use, forcing, hazard types and socio-economic, cultural and environmental characteristics. All selected regions are most frequently affected by storm surges and coastal erosion. A management guide of PMP measures and management approaches will be developed. The toolkit will benefit forecasting and civil protection agencies, coastal managers, local government, community members, NGOs, the general public and scientists.

## **1.2 Project structure**

The project is structured into seven Work Packages (WP) starting with WP1 on 'Data collection, review and historical analysis'; WP2–4 will create the components of the RISC-toolKIT containing an 'Improved method for regional scale vulnerability and risk assessment' (WP2), 'Enhanced early warning and scenario evaluation capabilities for hot spots' (WP3) as well as 'New management and policy approaches to increase coastal resilience' (WP4). The toolkit will be tested through 'Application at case study sites' (WP5). WP6 will be responsible for 'Dissemination, knowledge transfer and exploitation' and 'Coordination and Management' are handled in WP7.

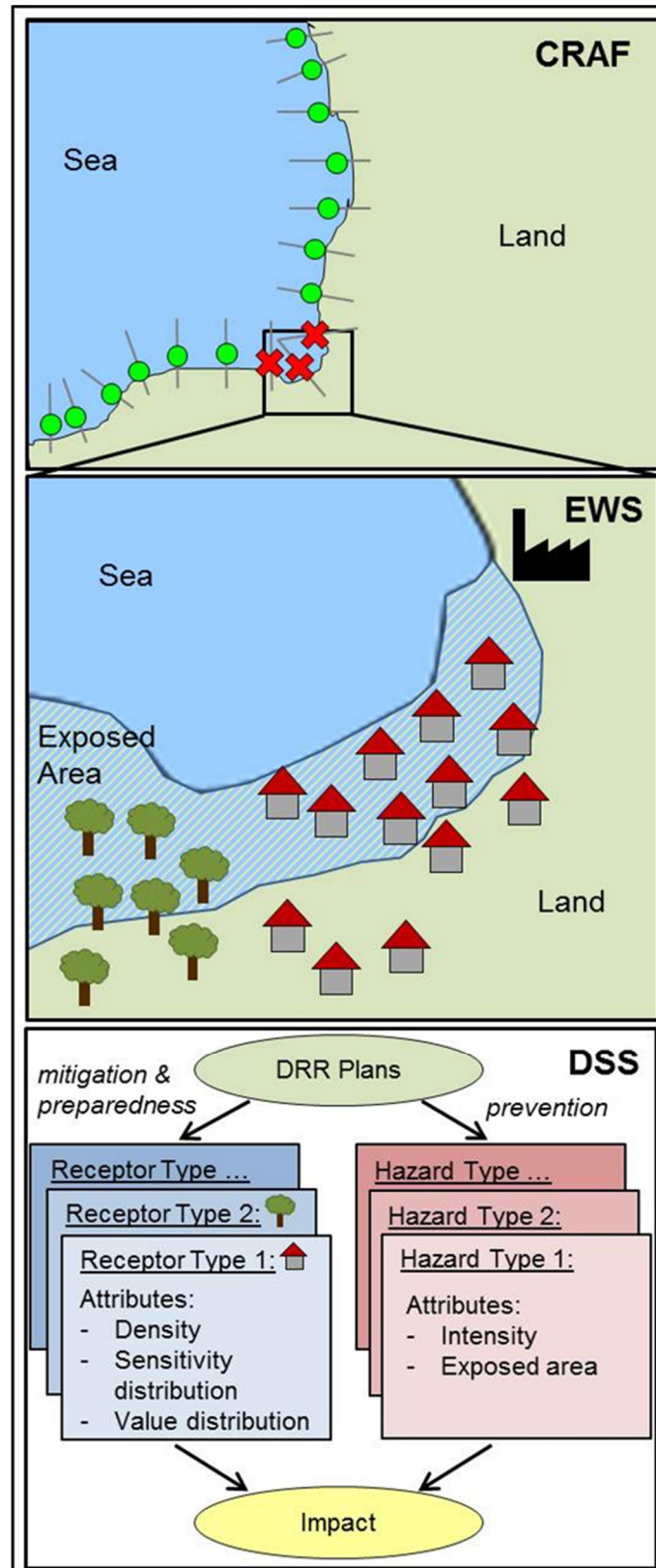


Figure 1.1: Conceptual drawing of the CRAF (top panel), the EWS (middle panel) and the DSS (bottom panel)



Figure 1.2: Case study sites (stars), RISC-KIT case study site partners (blue solid dots) and non-case study site partners (red open circles).

### 1.3 Deliverable context and objective

The current deliverable 4.4 is part of WP 4. The objectives of WP 4 are to:

- develop potential DRR measures;
- design site-specific DRR strategic alternatives and evaluate their effectiveness and feasibility after their application and scenario testing at case study sites in WP5;
- create a web-based management guide for developing integrated risk-reduction plans in other locations; and
- synthesise findings and provide recommendations for management and policy guidance.

This deliverable 4.4 reports on the last bullet. The scope of this report is defined in the Description of Work (DoW), Task 4.4:

“Task 4.4 will involve all RTD WP leaders (WP1-5) in order to synthesise the findings of the project. This synthesis will take the form of a report (D4.4) which will be publicly available for download on the RISC-KIT website. The report will showcase the findings of the RISC-KIT project and deliver insights and recommendations for the development of strategies and policies for improved disaster risk reduction both in Europe and elsewhere. The report will provide a user-friendly overview of the components of the RISC-KIT toolkit (Storm Impact Data Base, CRAF, EWS/DSS, Web-based Management Guide and MCA Guide) using accessible language and graphical illustrations. The report will furthermore provide recommendations in alignment with existing national and EU policies to manage coastal risks under shifting environmental, socio-economic and cultural conditions. To this end, the report will address multi-level risk governance approaches that align local needs with macro-level policy goals, or synergies with other policy areas (e.g. climate change adaptation, sustainability, resource efficiency) for increased impact and greater cost-effectiveness. In this way, project findings will provide insights for the planning and development of national and EU strategies and policies for increased disaster risk reduction, as well as support for the formulation of international strategies. This report will be submitted in abridged form to a leading international journal on environmental policy research.”

This deliverable is a final synthesis report that showcases the key outputs and findings of the RISC-KIT project. It also delivers insights and recommendations for the development of strategies and policies for improved disaster risk reduction both in Europe and beyond. The results will be made publically available through the project website and will feed the final RISC-KIT policy brief as well as be submitted as a journal article.

## 1.4 Approach

In accordance with the DoW, all WP leaders were involved in the compilation of this report in order to ensure that the Synthesis Report is based, not only on the deliverables produced, but also on the qualitative insights that the consortium gained over the 42 months of research and development activities. To this end, WP leaders were invited to a writing workshop in Berlin from 21-23 February 2017. Discussions were focused on findings from i) the development and application of the RISC-toolKIT at the local case-study level (summarised in Chapter 2) and ii) the achievement of the goals as stated in the DoW's “Progress beyond the state-of-the-art” (summarised in Chapter 3). Feedback from the RISC-KIT International Expert Board was also taken into account for the workshop. The resulting insights from the group concerned the planning and development of national and EU strategies and policies for improved DRR, as well as how to provide support to international strategies and their future development.

The core output of the project is the “RISC-KIT toolkit” to support strategies for increased resilience of coastal areas. One of the main aims of the Synthesis Report is therefore to provide a user-friendly overview of the toolkit produced and lessons learned from their application at the case study sites (Chapter 2). This Report has made extensive use of graphical illustration and tables to increase its readability and accessibility. In addition to the toolkit, the project undertook a number of other research and communication activities. In order to ensure these were also captured, the advances made beyond the state-of-the-art for each WP are also laid out in this Synthesis Report (Chapter 3). The achievements, lessons learned and challenges identified through the work at the local level in ten case study sites were considered in relation to their relevance to EU and international processes for coastal DRR and other policy areas such

as climate change adaptation and sustainable development (Chapters 4 and 5). In particular the insights were considered for their relevance to the EU Floods Directive (2007/60 EC) (FD) and the UNISDR Sendai Framework 2015-2020. In this way, the report addresses the multi-level governance of risk, aligning local needs with macro-level policy goals and highlighting synergies with other policy processes at the EU and international level. By highlighting some of the other policy areas of relevance to coastal DRR, actors from different levels and sectors are made aware of opportunities for integrated actions with greater cost-effectiveness and increased impact. The lessons learned and accompanying recommendations are divided into seven thematic sections and can be found in Chapter 5. The final Synthesis Report will be made publicly available at the RISC-KIT final end-user day in April and on the project website. The results have fed into the final RISC-KIT policy brief and it is planned to submit this Report in abridged form as a journal article.

## **1.5 Outline of the report**

Chapter 2 provides an overview of the tools and reflects on lessons learned. Chapter 3 discusses whether each element of the project (Work Package) has accomplished its objectives and how – where relevant – it has gone beyond the state-of-the-art as described in the DoW. Chapter 4 considers the macro-level policy goals at EU and international level for different policy areas e.g. biodiversity and sustainable development but in particular the UNISDR Sendai Framework and the Floods Directive. In Chapter 5, we summarise lessons from the development and application of tools and interviews conducted at the local level case study sites. The broader context established in Chapter 4 provides the basis for aligning these insights with EU and international processes. The lessons learned are then fed into a series of recommendations for improved DRR for Europe and beyond.



## 2 Toolkit

From 2013 – 2017, RISC-KIT worked to produce a set of open-source and open-access methods, tools and management approaches (“RISC-KIT toolkit”) to reduce risk and increase resilience to low-frequency, high-impact hydro-meteorological events in the coastal zone (see Figure 2.2). The toolkit contributes to different aspects of the DRR management cycle (see Figure 2.1: RISC-KIT tools and their alignment with the Disaster Management cycle (by Van Dongeren et al. (2017 forthcoming) and adapted from an original by and courtesy of C. van de Guchte, Deltares).

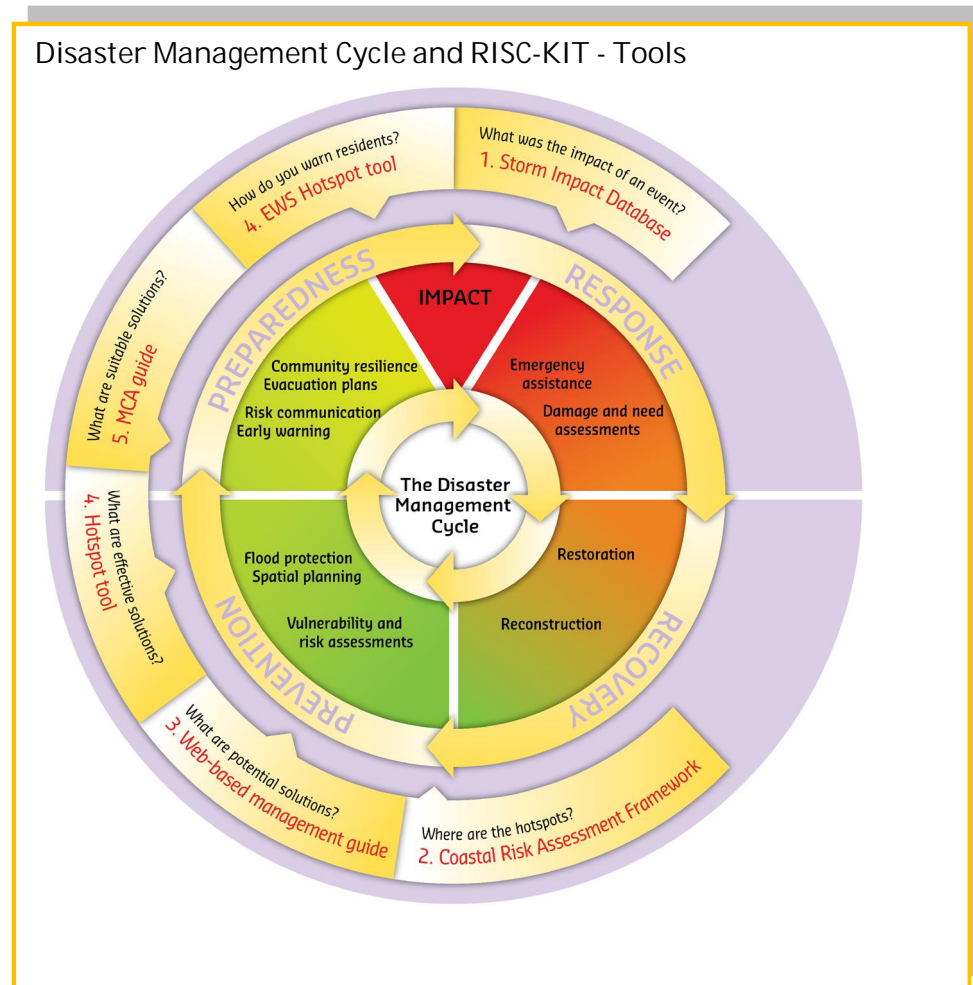


Figure 2.1: RISC-KIT tools and their alignment with the Disaster Management cycle (by Van Dongeren et al. (2017 forthcoming) and adapted from an original by and courtesy of C. van de Guchte, Deltares).

The toolkit provides on the one hand, tools for *information* (Storm Impact Database, Web-based management guide) and on the other hand, tools for *assessment* (Coastal Risk Assessment Framework (CRAF), the Hotspot Tool Early Warning System and Decision Support System (EWS/DSS) and Multi-Criteria Analysis (MCA)) (Figure 2.2) which were utilised at the project's 10 case study sites (see Figure 1.2).

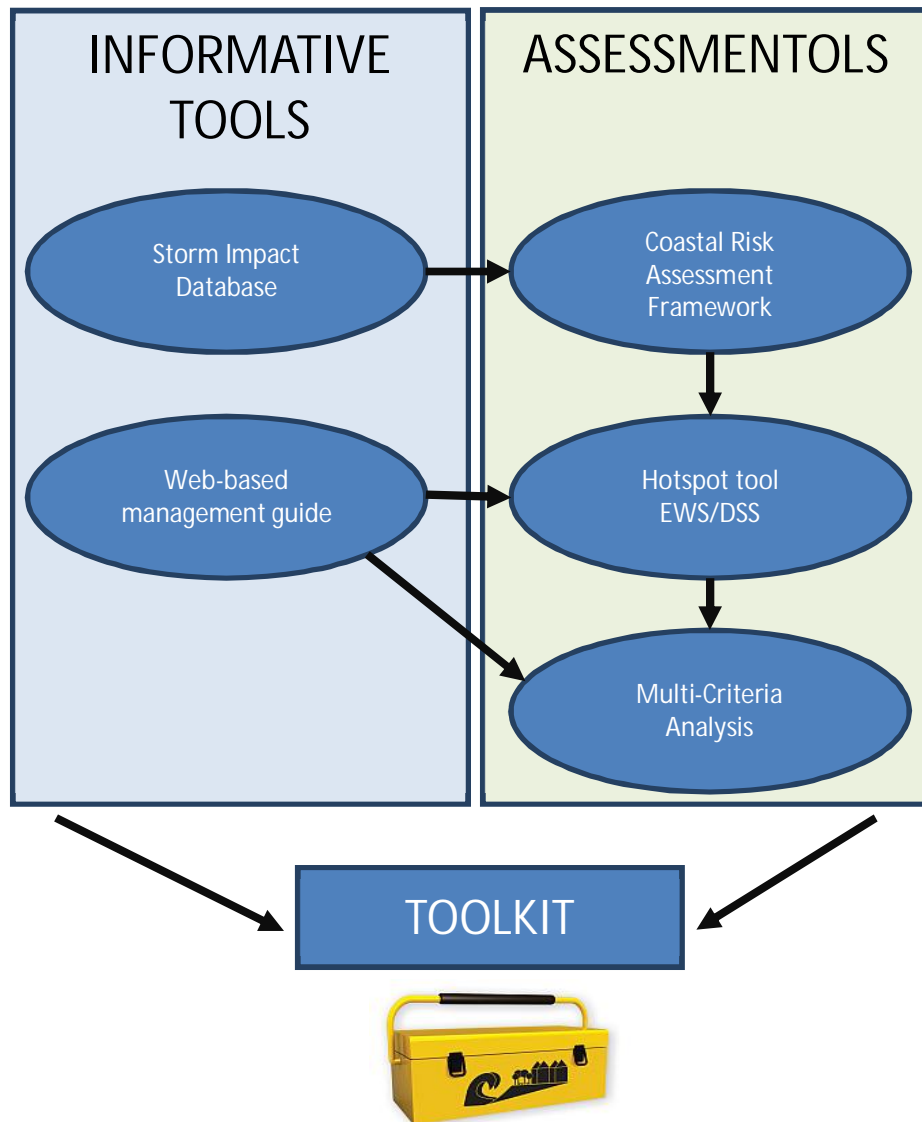


Figure 2.2: Overview of the RISC-KIT tools and their interdependencies

Producing tools that can be uniformly applied is challenging due to the diversity of coastal types and exposed elements. The RISC-KIT tools have therefore been designed with a broad scope so as to be widely applicable, acknowledging the need for the tools to be adapted for local use. This chapter provides an overview of the RISC-KIT “toolkit” and the lessons learned during their development, application and dissemination.

## 2.1 Storm Impact Database

### 2.1.1 Overview

The Storm Impact Database (WEB-GIS impact-oriented database) is a repository of information of the impact of historical storms (surges, winds, flash floods) in the case study areas. The basic description of the database can be found below, further details can be found in Ciavola et al. (forthcoming).

The Storm Impact Database has four main functions:

1. Uploading of storm event data
2. Viewing of storm event data and metadata
3. Web services for reuse of the storm even data and metadata
4. xml export to EU impacts database

The database includes not only physical but also socio-economic, cultural and environmental information. The tool aims to strengthen the efforts of local communities and national governments to apply the Floods Directive raising historical awareness of what has occurred, and lead to a better understanding of the stakes and vulnerabilities of the case study sites in a long-term perspective. Within the project, the database acts as a source of information on historical events and is a source of validation data for models and results used in DRR activities.

In the design, a key priority was the integration of RISC-KIT data with existing data and analysis tools collected from previous and ongoing projects, including the MICORE database of marine storms.

The tool consists of the following components (Figure 2.3):

1. A central database (PostgreSQL with PostGIS extension)
2. A web application
3. A GeoServer installation

Data upload is carried out by registered data managers on an event-by-event basis for each site by filling in a number of standardised data fields related to the event. The use of standardised fields ensures the data is stored in a uniform way and facilitates intersite comparisons and database queries. A minimum level of mandatory information is required for each event to be stored in the database, namely the country and region of the storm event (as defined using Eurostats NUTS nomenclature), the event start date, as well as a brief description of the event (e.g. synoptic type of the event, the name of the storm, unique characteristics related to the event etc.). Event data for the database are divided into three main data types: 1) Physical Data; 2) Impact Data; and 3) Supplementary Data.

Following access to the website the user is first directed to the overview map, where it is possible to visualise the number of events contained in the database by geographic region (for example, by zooming in on Europe). Cartography and satellite imagery are based on Google Maps and Google Earth. As of February 2017, the database contained 298 reported storm events, with the highest coverage in Italy (70 reported events), followed by Germany (66 events) and the UK (29 events).

The Storm Impact Database is published in the form of an open-access webpage available at: <http://risckit.cloudapp.net/risckit/#/>



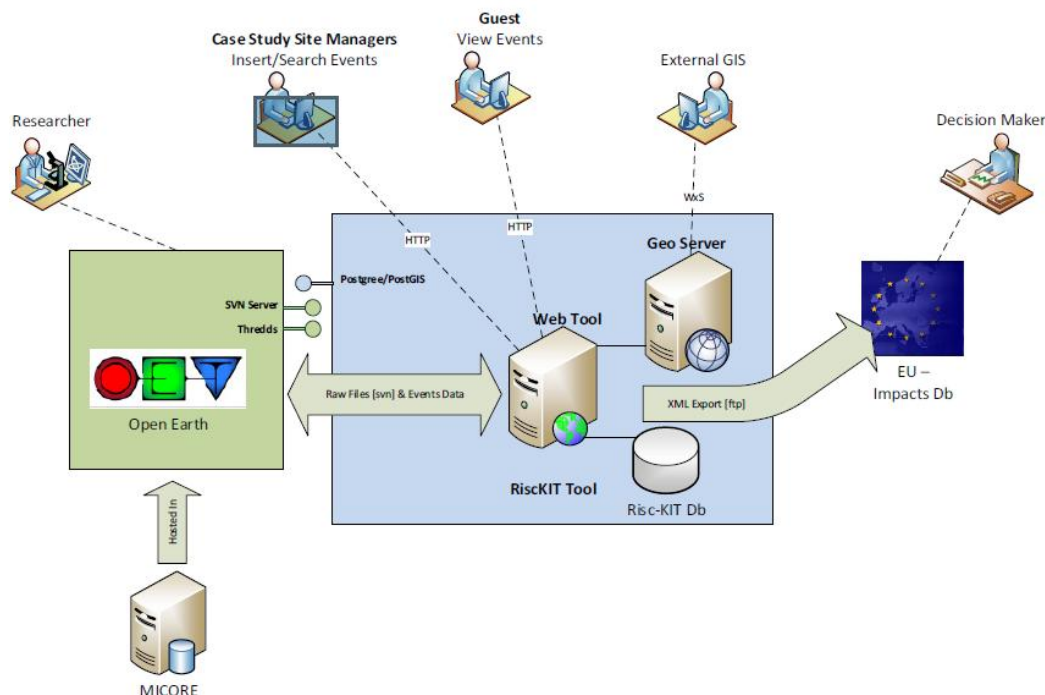


Figure 2.3: Schematic overview of the interaction between the Storm Impact Database (blue box) and the OpenEarth backbone (green box) including user interaction

### 2.1.2 Lessons learned from development of the tool

A fundamental goal of the database is to provide a framework for the reporting of extreme hydro-meteorological events in the future, in order to improve the way in which physical and impact data in particular are collected. A common observation made by case study site managers during the collection of data for the (currently 298) uploaded events is that impact data is best obtained immediately following the event and that, when left too long, is often too reliant on less-accurate newspaper reports rather than more primary sources (such as those collected by experienced practitioners). By already providing the data fields and impact categories required for event reporting, site managers are better prepared for data collection should an event occur. No cooperation was sought with insurance companies as it was considered most unlikely that they would have more detailed information than that collated by the RISC-KIT project. Furthermore, this avoided issues concerning the confidentiality of the information being shared. The use of impact data used for reimbursement of damages or requests for free loans from the government would imply the release of sensitive personal information, which clearly cannot be put into the public domain.

In terms of future development, the option of crowdsourcing data from the general community is compelling. This however would require a careful quality control of incoming data in order to avoid the insertion of spurious information that could de-value the database as a whole. It could be conceivable however, to permit authorised users, with a minimum of training in disaster response from both the physical and socio-economic aspects to report the events. Local coastal managers for example, would be ideal candidates as they could report to a central office in the government administration, where database managers could validate the information. The lessons learned from the development of the database are summarised in Table 2.1.

*Table 2.1: Lessons learned from the development of the Storm Impact Database*

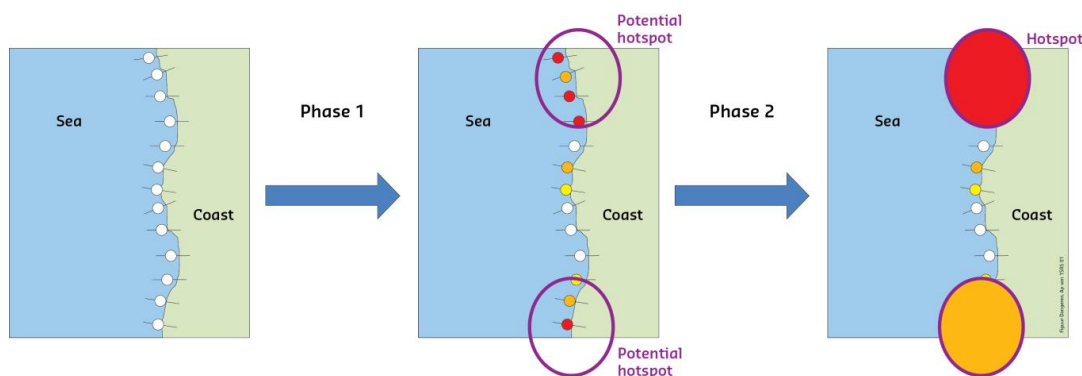
Tool	Benefits	Challenges	Future development
Storm Impact Database	<ul style="list-style-type: none"> <li>- Combines physical, socio-economic, cultural and environmental information.</li> <li>- Long-term perspective</li> <li>- Provides validation data for testing of DRR scenarios and tools</li> <li>- Provides framework for data collection and reporting</li> </ul>	<ul style="list-style-type: none"> <li>- Ensuring data is collected soon after event</li> <li>- Cooperation with insurance companies</li> </ul>	<ul style="list-style-type: none"> <li>- Crowdsourcing data from general public</li> </ul>

## 2.2 Coastal Risk Assessment Framework (CRAF)

### 2.2.1 Overview

The CRAF has been developed as a comprehensive, systematic tool, generic enough to be used across Europe and for multi-hazard assessment. The aim was to produce a framework that although uniform, does not take a one-size-fits-all approach and has the flexibility to be adjusted to local realities.

A two-phase approach is adopted for selecting the hotspots to facilitate the regional assessment process (See Figure 2.4). Firstly, a screening process for the “identification of hotspots” (Phase1) and the “selection of hotspot” via a more complex modelling process approach (Phase 2) that combines hazard and impact assessment models.



*Figure 2.4: Schematic overview of the Coastal Risk Assessment Framework (CRAF)*

#### *Phase 1: Identification of potential hotspots*

Along the coast, potential hotspots, i.e. sectors with a high potential exposure, are determined for different hazard indicators (e.g. wave overtopping, flooding and coastal erosion) and for different exposure indicators (land use, social, transport, utilities and economic activities; see Figure 2.5, upper panel). Results are presented in the form of a coastal exposure index, using the Coastal Vulnerability Indicator Library and the accompanying guidance document. The results of the CRAF Phase 1 are visualised in the web-based viewer.

### Phase 2: Hotspots risk analysis and selection

The potential hotspots are further analysed to identify the most critical hotspots based on current and future climate scenarios using more advanced hazard and impact assessment models (See Figure 2.5, lower panel) The models used are:

- XBeach (1D) a morphodynamic model to compute hazards of overtopping and erosion for selected return-period storms
- LISFLOOD: an inundation model to compute the hazards flood depth and velocities based on the computed overtopping.
- INDRA (Integrated DisRruption Assessment) to compute the impacts including risk-to-life, displacement, disruption and recovery of various categories and score the hotspots using a Multi-Criteria Analysis.

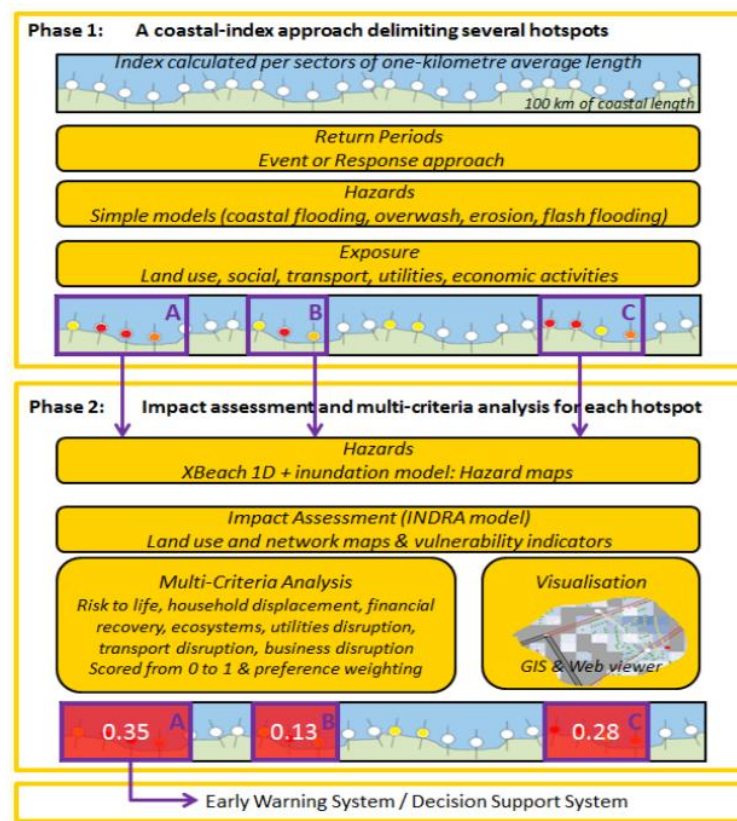


Figure 2.5: Coastal Risk Assessment Framework (CRAF) application sequence

### 2.2.2 Lessons learned from application of tool at case study sites

Phase 1 of the CRAF, although still requiring extensive databases and information, was relatively simple and quick to apply at the regional scale. The methodology permitted the correct identification of the vast majority of hotspots for almost all study sites, and a positive validation (via comparison with historical storms and field records) was achieved for the hazards assessed. The CRAF uses a coastal index - a measure for the combined hazard and exposure in a given sector - which can be recalculated by incorporating new data or regional DRR activities, defining how the hotspots will be affected. This means that not only the state, but the evolution of the

hotspot can be assessed, both as a result of physical processes, as well as coastal management interventions.

The CRAF 1 has inherent limitations, since it uses simple approaches, formulations, databases, and indicators. For some cases, e.g. for extensive interconnected low-lying areas or extremely complex alongshore morphologies, the method is too simple. The assumptions used throughout can therefore result in over- or underestimation of risk. In these more complex cases, the selection of a greater number of hotspots for analysis in Phase 2 of the CRAF is recommended, as this second phase makes use of more complex and robust models.

Prior to the application of the CRAF, project end-users were consulted in order to identify likely hotspots. The hotspots that ranked most highly after application of the CRAF Phase 2 mostly corresponded with these end-user estimations. The differences that did emerge highlighted the limitations inherent to selecting a hotspot without detailed analysis or by using expert judgment alone, and thus displayed the benefits of using the CRAF. Concerns about data availability existed in most case studies, but was addressed in all of them, in the worst case by using generic values or assumptions. The indicators with lower degree of confidence were “regional business disruption” and “household displacement”. As a result, the confidence in the impact assessment varied and it became difficult to perform an integrated regional assessment on business disruption including potential cascade effects.

Differences in stakeholder perspectives may lead to different results during the final CRAF assessment. In such cases, it is possible that agreement on the selected hotspot may not be reached. Where similar impacts are analysed at all hotspots within the same case study, then limitations in data quality, and differences in the indicator assessment and weighting are similar across the hotspots and therefore have less influence in the comparative assessment where hotspots are ranked. In other case studies the hotspots analysed differed from each other more substantially. For such cases only significant differences in exposure between the compared hotspots avoid any doubt relating to the ranking of the hotspots. Overall, and taking into consideration the limitations expressed above, the CRAF method proved to be robust in a wide range of applications, and can contribute to optimizing resources for coastal risk reduction.

The application of the CRAF was conducted in all case study sites where data was, at least partially, available. However, this kind of data is often not available all over Europe and differences on data quality are high. Inputs from existing European datasets could be consolidated and fed into the CRAF so that it can be run as a generic tool for different European coastal types in the future. This is in agreement with the Sendai Framework which highlights the need for comprehensive surveys, investment and long-term research and development on multi-hazard forecasting and early-warning systems (§25 (b)(i); §33 (b); §34 (c)). The CRAF provides concrete support to this approach as it is able to assess present and future risk due to multi-hazards. It also provides guidance on gathering relevant information to make a robust assessment.

Improvements on the CRAF development and application are mainly related with the use of increased, detailed, standardised and better quality (often not yet available) datasets regarding physical, social, economic, environmental and cultural information as a main tool to reduce the degree of uncertainty. The future development of the CRAF could also include exploring simple ways to include socio-economic and climate change scenarios. Methodologies for certain impact categories (e.g. health impacts, public services, heritage, cascading effects) could also be expanded and integrated into the CRAF's response-based approach. Improvements can also integrate the development of a user friendly interface that reduces the work of the user on

inputting data and guides it along the different steps, resulting into an organised IT based tool, for ease of use.

Application of the CRAF should be performed by a multi-disciplinary team composed of experts from different backgrounds (e.g., physical and social sciences) in order to be sure that all components are well captured and properly integrated in the final result. The lessons learned from the development and application of the CRAF are summarised in Table 2.1.

*Table 2.2: Lessons learned from the application of the Coastal Risk Assessment Framework (CRAF)*

Tool	Benefits	Challenges	Future development
CRAF Phase 1	Simple to use, quick to apply, can assess current state and evolution of coastal risk and is to be used as a first screening tool	Simplicity can lead to over- or underestimation of risk	<ul style="list-style-type: none"> <li>- Integrate existing European datasets</li> <li>- Integrate socio-economic and climate-change scenarios</li> </ul>
CRAF Phase 2	Robust, uniform framework that is adaptable to local realities, superior to expert judgement alone	Insufficient data e.g. on population displacement and business disruption; limited applicability to determine cascade effects due to lack of available quality data	<ul style="list-style-type: none"> <li>- Expand methodologies for impact categories (e.g. health impacts, public services, heritage, cascading effects)</li> <li>- Transform into software with user interface</li> </ul>

## 2.3 Web-based Management Guide

### 2.3.1 Overview

The RISC-KIT web-based management guide (FigureFigure 2.6) was created to facilitate EU-wide learning and exchange for the development of coastal risk reduction plans and provides a basis for the selection of measures to be evaluated with the Hotspot Tool (Chapter 2.4) and discussed using the Multi-Criteria Analysis Tool (Chapter 2.5). The guide is targeted at coastal managers as well as other groups concerned with coastal management (i.e. coastal resource users, technical and scientific experts and policy makers) in Europe and those facing similar challenges beyond the region.

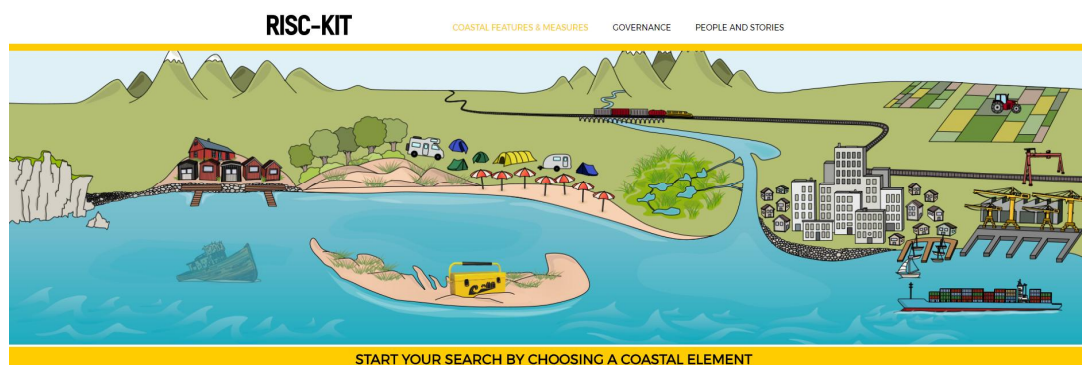


Figure 2.6: Screenshot of the Web-based Management Guide

A consultation was held with RISC-KIT end-users to establish needs and preferences for the web-based management guide. At the consultation, existing guides were tested, discussed and ranked. The architecture and appearance of the guide was then shaped according to the features highlighted as being of most interest and usefulness (e.g. use of case studies, a step-by-step guide, description of DRR measures and plans).

Coastal zones can be viewed through various lenses (e.g. bio-physical, socio-economic, political, cultural, historical etc.) which can be used to examine a wide range of subjects (e.g. coastal morphology, heritage, perceptions of risk, legal and administrative traditions, local economy etc.). The RISC-KIT web-based management guide provides a rich source of information on these subjects, and acknowledges the diversity and complexity of coastal zones by providing multiple entry points for the user to view coastal management and disaster risk reduction (FigureFigure 2.7).

For successful coastal risk reduction, it is necessary to establish an approach ('strategies') that is suited to the biophysical conditions of the coastal zone ('coastal features') and is informed by an awareness of human behaviour ('people and stories') and an understanding of the institutional arrangements ('governance") in place. From the website landing page, the user can choose through which of these lenses they wish to explore the management of coastal risks.



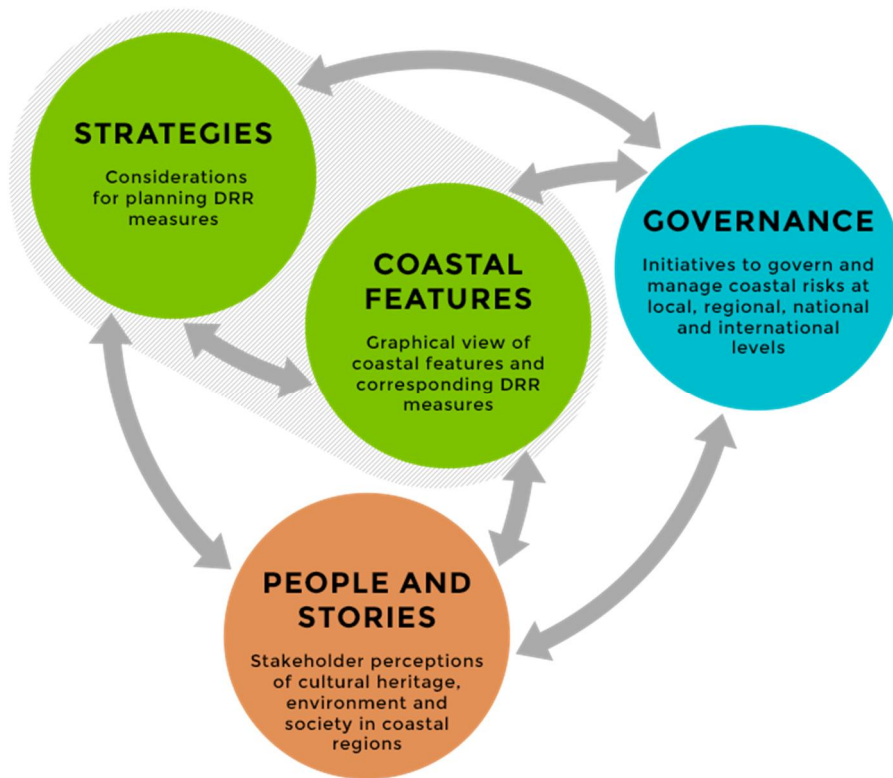


Figure 2.7: Core components of the RISC-KIT web-based management guide

The guide highlights key principles for the design and implementation of DRR plans and strategies in various socio-economic, cultural and environmental settings. Different 'coastal features' can be selected from a graphical map (see Figure 2.6: Screenshot of the Web-based Management Guide) which then produce a list of prevention, mitigation and preparedness measures appropriate for that biophysical context. Technical descriptions of the measures are accompanied by information on cost-effectiveness and practical illustrations of their application. Under the governance component of the guide, the RISC-KIT case studies are situated within their wider context and stakeholder perceptions of governance approaches are illustrated with interview quotations. Additional research was conducted to provide further contextual background pages on the governance setting for each country. Pages on EU and international initiatives for coastal DRR (e.g. EU Floods Directive and Sendai Framework) were also added to this end.

The RISC-KIT web-based management guide aims to provide new insights for all members of its target audience. For example, although coastal engineers might have a very good understanding of the technical aspects of coastal defence measures, they can obtain information on how the feasibility or acceptability of these measures can be affected by governance systems and public perceptions. At the same time, policy makers can gain insights on the range of DRR measures available and review examples of their application through examples and case studies.

### 2.3.2 Lessons learned from development of the tool

The web-based management guide was created to provide coastal stakeholders with a holistic view of coastal disaster risk reduction. In designing the guide, it was clear from the outset that a large amount of information, especially on DRR measures, was already available online. Rather than producing similar information to existing websites, it was decided to build on this work.

Collaboration was sought with the creators of other web portals and proved a positive and fruitful exchange on coastal protection and DRR measures. Existing sources (e.g. Climate-ADAPT and Coastal Wiki) were used as input into the guide and provide an excellent accompaniment to the outputs of the RISC-KIT project.

Furthermore, while descriptions of DRR measures provide a useful information base, the consultations with end-users indicated that including examples of practical implementation substantially increased the relevance of, and interest in, the guide. Additional research was carried out so that wherever possible each type of measure had an example or case study for illustrative purposes. These examples also draw on the 150 interviews carried out as part of RISC-KIT's empirical research (see Chapter 3.3.3 for details) which contextualise and provide further information on perceptions and experiences with the measure.

The guide provides information about governance at the local level of the RISC-KIT case studies as well as in their corresponding countries. The governance component of the guide begins with a description of policies and stakeholders involved in coastal protection, flood risk management and civil protection/DRR. However, the strong diversity in approaches meant that it became necessary to expand the description to include more general information on governance e.g. involvement of non-state actors, particular challenges or historical reasons for administrative divisions. This additional information enables the reader to situate the - very different - policies and approaches to coastal DRR in Europe within their broader context.

The guide was developed to provide enough detail for use at higher levels of policy and planning, and to provide examples of implementation for technical experts to draw inspiration from. Further developments can include increased and detailed technical information on DRR measures including co-benefits for other policy areas e.g. climate adaptation as well as and adding descriptions in other languages to increase the usefulness of the tool for more local users. The site could also be opened up for users to upload their own measures, case studies or comments. However, an interactive and continually 'live' web-tool would require a source of funding beyond the lifespan of the current project.

The lessons learned from the development of the Web-based Management Guide are summarised in Table 2.3. The Guide can be visited at: <http://coastal-management.eu/>

*Table 2.3: Lessons learned from the development of the Web-based Management Guide*

Tool	Benefits	Challenges	Future development
Web-based management guide	<ul style="list-style-type: none"> <li>- Expansive source of information that builds on both existing sources and new knowledge.</li> <li>- Integration of perspectives from engineering, natural science, social science and the humanities.</li> <li>- User-friendly and example based approach.</li> </ul>	<ul style="list-style-type: none"> <li>- Provide information that is useful to a range of stakeholders with different types of knowledge</li> <li>- Ensuring that the Guide is well disseminated</li> </ul>	<ul style="list-style-type: none"> <li>- Integrate/coordinate with future H2020 projects and other initiatives for coastal DRR.</li> <li>- Enable users to contribute</li> <li>- Add descriptions in other languages</li> <li>- Highlight synergies e.g. between climate adaptation and DRR</li> </ul>



## 2.4 Hotspot tool (Early Warning System/Decision Support System)

### 2.4.1 Overview

A quantitative, high resolution Hotspot Tool was developed to evaluate the effectiveness of DRR measures in hotspots e.g. as identified by the Coastal Risk Assessment Framework (CRAF) (see Chapter 2.1). The Hotspot Tool is a free-ware Coastal Early Warning System/Decision Support System (EWS/DSS) that is divided into two phases: planning and event phase.

#### *Planning phase*

In this phase, an evaluation of the effectiveness of DRR measures in hotspots is carried out. This is firstly done by computing the effect of selected DRR measures on storm impact with a model system. For the planning phase, hundreds of model simulations (both synthetic and historic storms) can be run, describing a range of storm conditions, physical setting and DRR measures. The choice of model framework can be tailored to each site.

The results of all model simulations and measured data are stored in a Bayesian Network. The Bayesian Network identifies probabilistic relations between storm characteristics and DRR measures, and local hazards and impacts. It can help design, assess and optimise DRR measures in the hotspot location (e.g., seawall versus flood-proofing). To set up a Bayesian network decision support system (DSS), a Bayesian Network adaptor (BN Adaptor) is needed, in this case, making use of the GeNie freeware.

#### *Event phase*

In the project, Delft-FEWS (Flood Early Warning System), originally developed for river flooding application, was extended to be used on coasts. This system allows for real-time surge, wave and coastal erosion and flooding predictions to be made. Model adaptors were developed or improved in order to work with models such as XBeach, Delft3D, TELEMAC, SELFE and SWAN.

The results of the Hotspot tool are visualised in a web-based viewer at <http://al-ng017.xtr.deltares.nl/riskkit/index.htm>

In the application of the tool, the assessed DRR measures were grouped into hazard influencing measures and vulnerability and/or exposure influencing measures. Future predicted climate scenarios incorporated at the EWS/DSS systems included sea level rise and extreme storm surge levels, based on available projections, projected by 2050 (or by 2060 depending on available data). In cases where future predicted climate by 2050 would result in limited increase in hazard intensity and impact, climate change scenarios projected by 2100 were used.

The developed tool was able to translate the relevant hydraulic boundary conditions into hazard intensities and impacts at specific receptors, which provide coastal managers, decision-makers and policy makers with systematic information to detect, monitor and forecast potentially hazardous events, and analyse the risks involved. The system can be adapted and extended to more boundary conditions, receptors, local hazards and impacts, so to enhance disaster preparedness for effective risk reduction for further events or morphological conditions. When a site is exposed to more than one local hazard, the developed EWS is able to assess and make comparisons about their relative importance in terms of hazard intensities and impacts. The comparison of the effectiveness of DRR measures, or of a combination of measures (strategic alternatives), was performed by changing the model set-up, re-simulating local hazards or

changing receptor and vulnerability information in the used Bayesian network, and by including new nodes and bins in it.

#### 2.4.2 Lessons learned from application of tool at case study sites

Improvements to the EWS/DSS can be achieved over time by developing specific aspects of the tool. In order to improve hazard simulation it is recommended to improve the quality and accuracy of the underlying numerical model trains. This can be achieved by increasing validation against field data. Although there are no technical limitations to the complexity of the model framework, increasing complexity may result in high demands in terms of data, computational time and resources. Hazard information derived by this model train is input to the Bayesian DSS where the impact of hazards on different receptors is studied. By increasing the number of geographical subdivisions of the hotspot and increasing the number of bins and model runs receptors and vulnerability relationships can be studied in more detail. Except for more detail with regard to currently studied receptors it is recommended to extend the DSS with inclusion of regional-scale systemic and indirect impacts of storm events at the hotspot. Amongst others the DSS includes vulnerability and/or exposure influencing measures. It is recommended to assess the uptake/operation/effectiveness of these measures. In line with the need for hazard simulation verification this can be achieved by determination of these factors for each case study site by of historical analysis to other (observed) hazards/events. In addition the effectiveness of DRR measures can be analysed by including more aspects linked to the probability of occurrence of events, economic value, and socio-cultural characteristics of the local stakeholders. Difficulties were mainly related with the assumptions needed for the implementation of non-primary and less tangible (e.g., education, awareness) measures.

The EWS is developed using the Delft-FEWS software. The Delft-FEWS software is a flexible tool that allows for integration of many different data types and models. This integrating process of different datasets and models requires a certain level of expertise and is potentially a time consuming process. Since most end-users do not do configuration as a routine job its recommended to make this process more user friendly. The EWS Client is used by forecasters and decision makers at expert level. In addition the webviewer can be used with limited prior knowledge of underlying physical processes and the EWS software. It was a useful tool during the Multi-criteria Analysis workshops and it is recommended to further develop the web application to make it more user friendly. Development of the webviewer (thin client) and the Delft-FEWS Client (thick client) can be a combined effort. Both applications can share configurations or may even be fully integrated. Further integration will improve consistency and limit implementation effort. The lessons learned from the development and application of the Hotspot Tool are summarised in Table 2.4Table 2.1.

*Table 2.4: Lessons learned from the application of the Hotspot Tool*

Tool	Benefits	Challenges	Future development
Hotspot tool (EWS/DSS)	<ul style="list-style-type: none"> <li>- The EWS can assess multiple hazards for their relative intensities and impacts</li> <li>- The tool can be used both as ex-ante planning tool in addition to as an</li> </ul>	<ul style="list-style-type: none"> <li>-High demands in terms of data, time and resources for hazard simulations</li> <li>- complexity of</li> </ul>	<ul style="list-style-type: none"> <li>- increase quality and accuracy of the numerical model trains</li> <li>- improve vulnerability relationships and detailed receptors</li> </ul>

	EWS in the event-phase - The generic configuration of the tool allows for extension to additional case study sites	software configuration -joint development of web-application and Delft-FEWS software.	- extended analysis of the effectiveness of DRR measures - inclusion of regional-scale systemic and indirect impacts of storm events at the hotspot. - Further extension of the Delft-FEWS software towards impact forecasting.
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## 2.5 Multi-Criteria Analysis Tool

### 2.5.1 Overview

A Multi-Criteria Analysis tool (MCA) was used to assess the proposed measures in each of the RISC-KIT case studies with respect to criteria that capture the key dimensions of the decision-making process. The methodology was informed by the participatory approach of Soft Systems Methodology, which addresses complex issues in a systematic way by engaging relevant actors to constructively discuss desirable and feasible options to solve local problems (Checkland and Poulter 2006). In RISC-KIT, local actors involved in coastal management were invited to participate in a one-off workshop to discuss and rank, from their own perspective, the (previously tested) DRR measures.

The effectiveness of measures - as defined by the Bayesian Network – formed the basis of the MCA. Key information was presented in non-technical language through a set of interactive cards (Figure 2.8) for stakeholders to understand the different possible measures and combinations of measures ('strategic alternatives'). Stakeholders then completed scoring sheets for each measure or strategic alternative on a scale from -2 (probably no) to +2 (probably yes) according to three criteria: feasibility, acceptability and sustainability.

A measure or strategic alternative that was deemed feasible could at the same time be deemed unsustainable or unacceptable. Thus, the scoring sheet system highlights both the benefits and drawbacks of each measure according to different criteria. Stakeholders were then handed out 8 stickers to weigh criteria. Weights indicated the perceived importance of criteria independent of the measures and relative to the objective of the process (e.g. what criterion is most important to consider if sand dunes were to be implemented to reduce coastal erosion?). Heavier weights (i.e. the more stickers a criterion received) indicated higher importance. The scored measures and the weighted criteria provided a final result on the overall ranking of options and revealed the least and most preferred measures amongst stakeholders. Figure 2.9 indicates the steps involved in the MCA implemented in RISC-KIT.

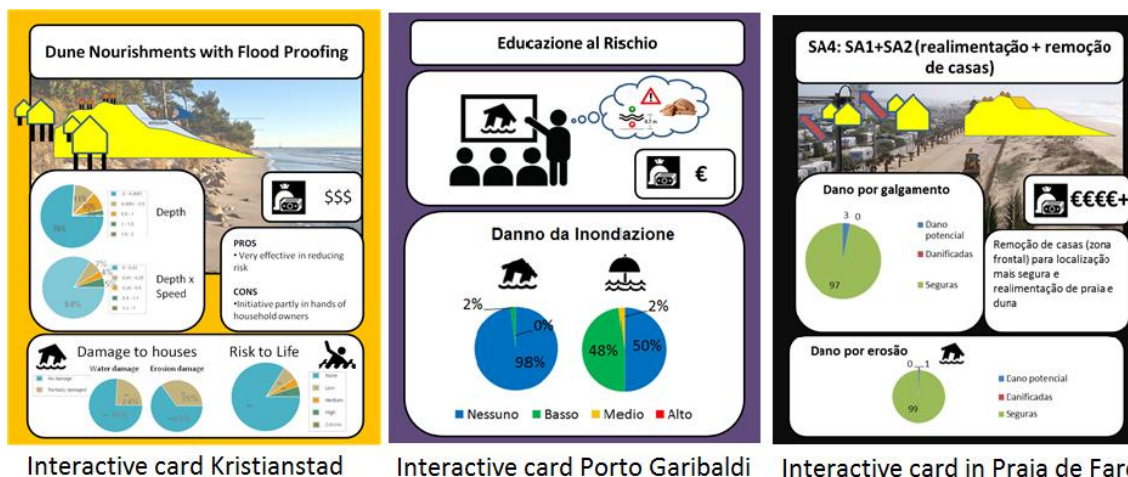


Figure 2.8: Examples of interactive cards in three RISC-KIT case study sites

The purpose of the MCA was to bridge the disciplinary divide between engineering sciences and social sciences, facilitate the communication and dissemination of local coastal risk assessments and evaluation of Disaster Risk Reduction (DRR) measures to a broad range of stakeholders. The methodology was designed to integrate scientific knowledge with stakeholders' knowledge to understand and assess the possible social, political and economic implications of different DRR measures, which could foster or hinder successful implementation.

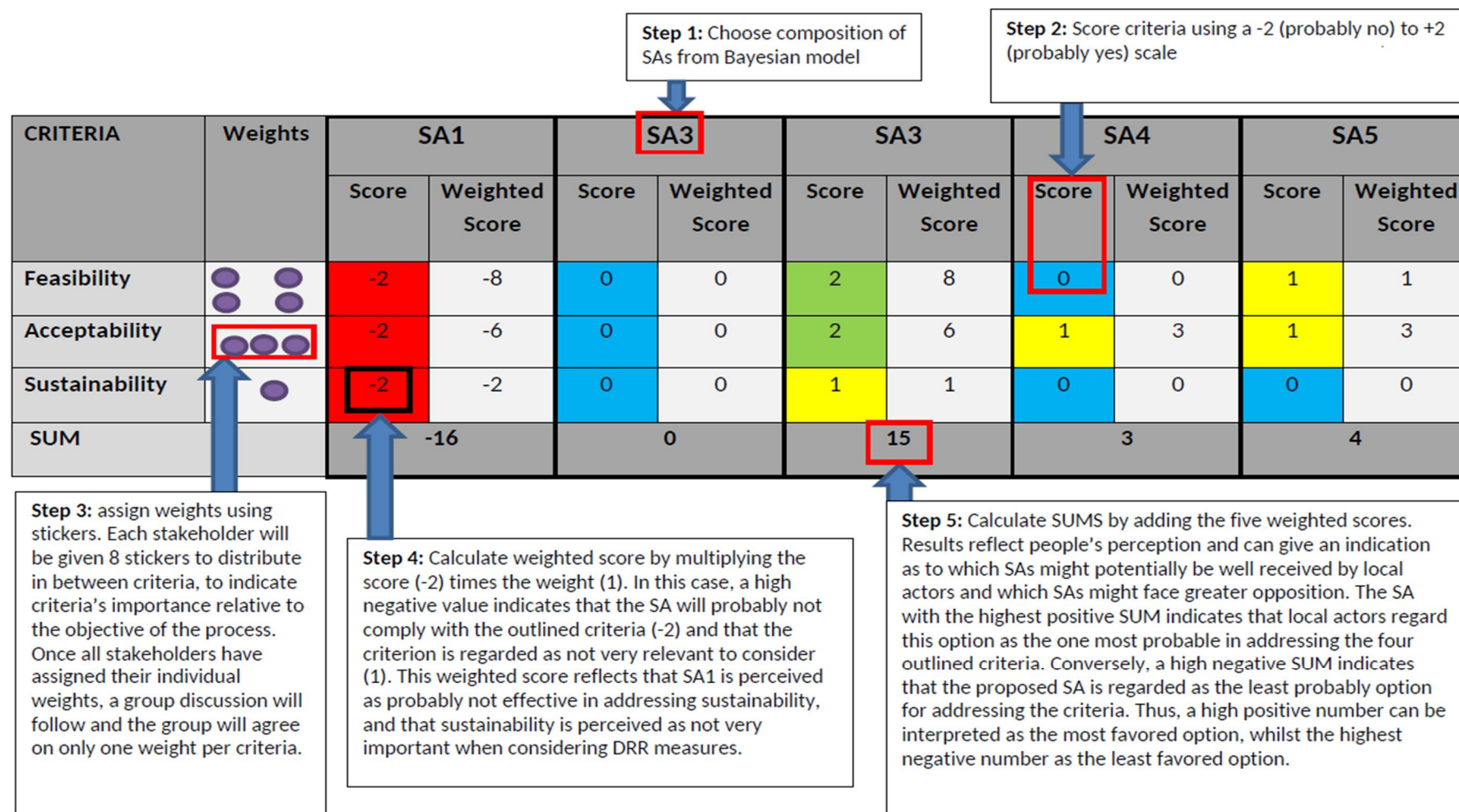


Figure 2.9: Steps to complete an MCA



## 2.5.2 Lessons learned from application of tool at case study sites

In RISC-KIT the MCA was expected to generate greater understanding on the extent to which options create value by achieving objectives, identify the areas of greater and lesser opportunity, prioritise the options, clarify the differences between the options, and help the key players to better understand the local situation. In practice, the use of the MCA in the project allowed each case study to test assumptions on the dynamics between DRR measures and between these measures and the specific social contexts, as well as to observe the reaction and responses from local actors to these measures.

The value of the MCA methodology varied from case to case. For the cases with richer experience of DRR work like North Norfolk or Porto Garibaldi, the MCA was a useful tool to communicate results and engage in an interactive exercise. For the cases where disasters occur with less frequency like in Kristianstad or Varna, the MCA was able to further generate discussions, create an initial enabling environment for cross-sectoral cooperation, increase awareness of risk and measures amongst civil society, and help communicate public concerns and expectations to managing authorities. In all cases, the MCA was a useful tool to disseminate the project results and methodologies, raise awareness on risks and potential measures, and improve local connections between stakeholders involved in coastal management. Generally, the MCA workshop was a good forum for bringing people together, a good exercise for testing our research assumptions and for obtaining better understanding of the divide between research priorities and coastal management.

Future developments of this tool could be done by including data on costs and benefits in the short and medium terms. This would allow participants to make a more informed choice in the exercise but also increase awareness of the benefits and drawbacks of different types of measures. This is relevant when comparing structural and non-structural measures; in particular for contrasting the economic, social, and ecological gains of nature and ecosystem-based solutions where the medium and long-term benefits might be greater than the short-term ones. The lessons learned from the development of the database are summarised in Table 2.5.

*Table 2.5: Lessons learned from the application of the Multi-criteria Analysis Tool (MCA)*

Tool	Benefits	Challenges	Future development
Multi-criteria Analysis	Communication of results, stakeholder engagement, and interaction between civil society and government, cross-sectoral cooperation, increased awareness of risk and measures.	Ensuring participation and motivation of all relevant participants; training non-social scientists to conduct participatory MCAs.	Include cost-benefit assessment.

### 2.5.3 Conclusions on the toolkit

The RISC-KIT toolkit contains both informative and assessment tools that can provide substantial support to coastal disaster risk reduction. The informative tools (Storm Impact Database and Web-based Management Guide) combine information on physical and environmental features of the coast with information on society, culture, history and governance. These tools demonstrate the relevance of RISC-KIT's interdisciplinary and holistic approach to understanding and reducing disaster risk and provide practical examples of how this integrative approach can be applied.

The Coastal Risk Assessment Framework (CRAF), Hotspot Tool and Multi-criteria Analysis (MCA) constitute a suite of assessment tools which allow areas of coastal risk to be identified, the effectiveness of existing and future DRR measures to be assessed and for these to be ranked and agreed upon with stakeholders. The application of the CRAF and Hotspot tool at ten case study sites with different forcing, morphological and exposure/vulnerability conditions reinforces the robustness of the methods and their wide potential of application. They are therefore valuable instruments for coastal management and risk reduction. With regards to the application of the MCA tool, the workshops provided an excellent opportunity for stakeholders to come together; in many cases triggering connections between actors who were previously unknown to one another. The MCA workshops were able to raise awareness of local risk and measures for prevention, protection and mitigation.

Before the tools were used, case study partners were trained to ensure correct and effective application. The tools have been applied and validated (for the cases of CRAF and EWS/DSS) at all case study sites. The validation was performed by comparing the findings (e.g., identified hotspots, erosion or flooding levels) against historical storms and field records. Depending on their personal background, case study owners (consortium members responsible for particular case study sites), and project partners found this process more or less challenging. The CRAF and the Hotspot tool were effective in selecting and ranking hotspots and in impact assessment at the hotspots, including testing and evaluation of DRR measures. They should nevertheless be further tested, validated, and applied at other coastal areas in order to increase their robustness and to test their limitations. In addition, the lack of high-quality and high-resolution socio-economic and impact data was observed at a European level and is the primary limitation to further development of such methods.

With regards to the MCA, the primary challenges were presented by the fact that many of those using the approach did not have backgrounds in the social sciences or in applying participatory approaches. Although the project team was trained before leading the workshops, some had concerns about conducting research with a method that was away from their own personal routine. Yet after the work had been conducted, the response from case study owners and the research team was overwhelmingly positive. In this instance, as with the informative tools (Storm Impact Database and Web-based management guide), the RISC-KIT project has demonstrated the benefits and necessity of taking an interdisciplinary approach to coastal DRR as well as practical ways in which this can be achieved.

The Technology Readiness Level (TRL) is a commonly used measure to estimate technology maturity of a given product. Table 2.6 outlines TRLs as defined within the

European Commission's Horizon 2020 Research and Innovation Programme (COM, 2014).

*Table 2.6: Description of Technology Readiness Levels (TRLs)*

Technology Readiness Level (TRL)	Description
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Although it is not an explicit goal of the RISC-KIT project to define the TRL level for each developed tool, Table 2.7 indicates the degree of development of the tools. This is particularly challenging for tools that integrate physical, engineering, natural, social, economic and cultural aspects as is the case for most of the RISC-KIT tools.

*Table 2.7 Technology Readiness Levels of the RISC-KIT tools*

Tool	TRL
Storm Impact Database	<i>TRL 6: Technology demonstrated in relevant environment.</i> The system was developed and already assessed and used by external users. External users have requested to add their own data.
CRAF (Phase 1)	<i>TRL 7: System prototype demonstration in operational environment.</i> Phase 1 of the CRAF was successfully demonstrated in 10 different case study locations and has been applied by partners in other areas as well (Denmark, West Africa, Pacific Islands).
CRAF (Phase 2)	<i>TRL 6: Technology demonstrated in relevant environment.</i> Phase 2 of the CRAF was successfully demonstrated in 10



	different case study locations, demonstrating the tool's value for coastal management. Compared to CRAF Phase 1 however, Phase 2 has not yet been implemented in other pilot projects and is not yet at the development level to be applied operationally
Web-based Management Guide	<i>TRL 8: system complete and qualified.</i> The Web-based Management Guide is fully developed and operational. It was also validated by case study owners and end-users.
Hotspot (EWS/DSS) tool	<i>TRL 6: technology demonstrated in relevant environment.</i> The Hotspot Tool was successfully demonstrated at 10 different environments.
MCA	<i>TRL 6: Technology demonstrated in relevant environment.</i> The MCA is fully developed and ready to be applied. It was also validated by case study owners and end-users.

## 3 Project achievements

From the outset, the RISC-KIT project had a clear understanding of the state-of-the-art on which it would build and had a vision on how to use the building blocks developed thus far to make progress. This chapter describes the state-of-the-art (baseline) at the project's outset, the outlined ways in which the project planned to progress beyond the state-of-the-art, both of which are taken “verbatim” from the Description of Work, and the project's actual advances. The information is organised according to the project's Work Packages as set out in the agreed outline (Description of Work). This allows for an assessment along four key questions: i) how did we accomplish what we promised? ii) what did we not do and why? iii) where did we go beyond what was promised? and iv) future directions.

### 3.1 Impact-oriented database of case study site and historic event data (WP1)

#### 3.1.1 Baseline

At the outset of the project, Europe lacked a comprehensive database of marine storm occurrence and their impact on all European coastlines. In some cases national databases combining hazards and impacts exist, but often only contain data collected after World War II. However, recent work had highlighted the value of matching historical sources with the collection of geomorphological evidence.

A number of database efforts on the hazards alone were supported by the EU: FP4 CODECS, provided a database of instrumental records for the last 300 years, and qualitative information for the last 1000 years, but was restricted to the European Atlantic coast; FP6 Hydrate provided a database for flash floods, and FP7 MICORE provided a historical storm database with data from nine sites across Europe. These databases were geographically rather than event-driven and were focused only on hazards.

In the United States, NOAA has classified all observed storm events and assessed their effects on property and infrastructure. As a result of this initiative, the NCDC (National Climatic Data Centre) is now able to compile data soon after the occurrence of an event. With this in mind, the RISC-KIT consortium considered there to be an urgent need to expand the existing databases available for Europe to encompass the diverse coastlines of the EU, and to develop appropriate protocols for assessing coastal storm impacts that reflect Europe's littoral diversity.

#### 3.1.2 Planned progress beyond the state-of-the-art

The first advancement beyond the knowledge base will be the expansion of the data set with historical sources. The collaboration between reinsurers and historians will strengthen the efforts of local communities and national governments to apply the Floods Directive. The reconstruction of the human and financial costs in the current coastal setting caused by events comparable to those in the historical analysis, will lead to better understanding of the stakes and vulnerabilities of the case study sites in a long-term perspective (>200 years) and will strengthen prevention and the

preparation strategies for extreme events. In addition, the knowledge gained will supply examples regarding memory of risks, which will constitute useful tools for mediation with elected representatives and local communities.

The second advancement is the inclusion of socio-economic, cultural and environmental information (where possible from interviews of contemporary witnesses) to characterise the impact of the events. The social and economic aspects of post disaster appraisal will also be examined, as well as cultural and health related aspects such as the number and type of casualties experienced both during and after an event. This approach will build on the FP7 KULTURISK. In its coastal case studies, that project focused only on sea-level rise, flash floods and marine flooding and did not consider other coastal threats like damage to coastal infrastructures or the occurrence of extreme coastal erosion leading to failure of the first line of defence (dykes or dunes).

The third advancement is that the database compiled in the RISC-KIT Project will integrate data from different hazards will be multi-hazard (storms, surges, winds, flash floods) in a systematic way, contributing to the work already started by the CRED Database which contains essential data on the occurrence and effects of over 18,000 mass disasters in the world from 1900 to present and is thus not only restricted to coastal events.

Summarizing, a more complete and impact-oriented database will be created. This type of database is not publicly-available as of now, despite efforts at the European (DG-ECHO, EEA, JRC) and Global (UNISDR) level.

### **3.1.3 Project advances**

In answer to the first advancement the project was able to produce a Europe-wide database of storm impacts including historical information (Garnier et al., 2017 forthcoming). Unlike previous efforts which have only had regional coverage this database provides coverage of all regional seas. We did not include datasets of insurers as these entities are very reluctant to share and make public datasets. The information entered in the database is so far limited to the countries where project partners are located, the case study sites and adjacent coastlines. For Italy, we included more information than just the two case study sites as storm impacts could be tracked across several neighbouring regions. This proved that assuming availability of operators willing to format and input the data, the database is capable of analysing information at European scale. Moreover, a successful attempt to extend the database to a non-European site, i.e. Bangladesh, proved that this approach is also able to log much wider impact events like hurricanes or cyclones.

For the second advancement, one limitation was the availability of socio-economic historical impact data, for example in the Ria Formosa case study site, which was settled less than 200 years ago. On the other hand, other sites like North Norfolk were able to provide information dating back over several centuries. Interviews with witnesses of 20<sup>th</sup> and 21<sup>st</sup> century disasters were generally limited for several reasons. Firstly, if the disaster occurred before WWII, only few survivors are still alive. Secondly for recent extreme events like Xynthia, the situation was too sensitive to intervene due to local tensions among the population and with institutions. For these reasons, it was not possible to obtain a statistical sample stakeholders and the number

of interviews conducted was focused instead on speaking to key informants where possible.

For the third advancement, only data on marine hazards is generally contained in the database as combined flash flood-marine inundation hazards existed only in the Liguria and Emilia-Romagna site. Also, although the possibility of exchanging data with the CRED database was explored, we found that that system's architecture was very different and missing the level of detail required by the RISC-KIT project. In terms of future development, a first step would be to ensure the case study sites are updated (these are current up to the winter season of 2014/15 when WP1 of the project was completed). The database could then be expanded to include more information and create links to other sites e.g. from UNISDR and EEA, although in as yet, these other systems do not gather as detailed information as was done by RISC-KIT. The database could also be fully rolled out to the European level by including nation-wide data from all Member States. The design is already fully compatible with the INSPIRE Directive (2007/2/EC) and the guidelines produced for Member State reporting on the Floods Directive (European Commission, 2013). A European roll-out would require identifying national authorities with the resources to be able to contribute to this effort, but would develop this into a comprehensive and extremely useful open-access resource. The database could be used to link storm impacts in different regions across Europe and thus inform trans-boundary decision making on DRR, in line with the aims of EU civil protection.<sup>1</sup>

## **3.2 Improved methods for regional-scale coastal vulnerability and risk assessment (WP2)**

### **3.2.1 Baseline**

At the outset of the project, there were no tools generic enough to be used uniformly across Europe to assess coastal risks, particularly those risks resulting from multiple, synergistic hazards such as overtopping, breaching, and erosion.

Firstly, many methods to assess extreme events-induced hazards (i.e. not risks) at the regional scale (~100 km) use external variables that solely describe the boundary conditions (e.g. wave height, water level and sea level rise) of the hazard and not the hazard itself. In most cases this characterisation of the hazard is based on an adaptation of the Coastal Vulnerability Index (CVI).

Secondly, on coasts, existing river flood risk assessment methods (GIS-based flood mapping) misrepresent the risk because the non-stationarity of surge and flash flood events. Also, the morphodynamic response of the coast has a strong effect on the flooding of the hinterland.

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<sup>1</sup> i.e. 'to support and coordinate the civil protections of Member States' (Treaty of Lisbon, Art. 196) and 'encouraging cooperation between Member States in order to improve the effectiveness of systems for preventing and protecting against natural or man-made disasters'. (Council Regulation (EU) 2016/369 of 15 March 2016 on the provision of emergency support within the Union, Recital 7).

Finally, risk assessment is at present restricted to directly-exposed elements. This is insufficient for understanding the impacts on the entire system and the system response.

However, the established concept of two components of hazards and vulnerability contributing to risk can be used and improved upon for coastal applications.

### **3.2.2 Planned progress beyond the state-of-the-art**

The first advancement will be to derive the hazard itself (e.g. erosion, wave run-up and overtopping) from the external boundary conditions using physics-based models which properly consider the nonlinear dynamics of the processes involved. In particular, we shall develop an efficient 1D (transect) version of the XBeach model to be used at regional scale across most coastal typologies. Thus, this methodology will allow associating probabilities of occurrence not just to the forcing elements (waves, surges) but also to the hazards (erosion, inundation). This is especially relevant as most of the considered hazards depend upon more than one or two variables.

The second advancement is to consider various forcing terms and their associated probabilities and to include all these in the probability of the hazard itself. To do this for all potential coastal hazards, the methodology previously developed by RISC-KIT partners, will be extended.

The third advancement is in the assessment of the vulnerability of exposed entities, where we will better recognise the variation in the sensitivity value of groups in response to external factors, such as the characteristics of the hazard, the nature of the surrounding environment, and the existence of DRR measures. This will be done by developing a consistent and exhaustive library which will enhance the vulnerability assessment of the exposed entities and will make vulnerability comparable on a pan European scale.

Fourthly, we will evaluate the long-term risk based on the resilience of the system, i.e. the ability of a system or a sub-system to return to the prior state after a disturbance, and thus stimulate sustainable coastal development. A key challenge is to incorporate additional non-monetary social indicators such as the Human Development Index and the Wellbeing index.

Finally, rather than focussing on directly-exposed elements, RISC-KIT will advance knowledge by considering potential ripple effects within and between the socio-economic systems inside and outside the immediate disaster area, and develop specific indicators to reveal the vulnerability of the system as a whole. Since the consequences of a shock on a system are dependent upon the structure of the system, it is a key challenge to explore agent-based modelling and general systems modelling to give a greater understanding of what the critical determinants in the effects of a shock are.

### **3.2.3 Project advances**

On the basis of simple models and the bathtub approach (a given area becomes inundated if its elevation is less than the water level), Phase 1 was able to consider a range of hazards (e.g., erosion, overwash, overtopping etc). These provided the flexible and efficient levels necessary for the screening process. The first advancement was achieved with CRAF Phase 2 in which the XBeach 1D model was selected and updated

to optimise its usability per sector (between 5 or 10 transects per km, given the computational constraints).

For the second advancement we have adapted the response-based approach. The CRAF has been based on the definition and quantification of the storm-induced hazards in probabilistic terms over a period long enough to be representative of the storm climate for the area. The final result is a set of probability distributions for different hazards along the coast, in such a way that, for a given probability the magnitude of the considered hazard can be consistently compared along the coast.

The third advancement is the Coastal Library. It has been produced in the form of a user-friendly Excel file and provides a comprehensive and generic set of indicators and methods to be used across Europe to input into any coastal impact assessment approach for ecosystems, the built environment, the human population, transport, utilities and business. Pre-existing information available in the grey and peer-reviewed literature has been integrated where appropriate. Other data and methods (e.g. step-wise approach for network vulnerability assessment, methods for including DRR measures in vulnerability assessment) have also been developed for assessing indirect impacts and impact reduction using DRR measures.

To answer the fourth and fifth advancement the CRAF has been created to consider both direct and indirect impacts integrating the hazard and vulnerability components previously mentioned, i.e. the potential risk to the population during an event, the household displacement, the household and the business financial impact, the business disruption, the impact on ecosystem, the transport disruption and the potential loss of critical services (e.g., water, electricity). However, it was not possible to consider all type of indirect and cascading impacts (e.g. ripple effects between systems) in the analysis. Such consideration will have added such complexity and such level of data requirement to the CRAF that it will have limited its potential application to the case studies.

Indices such as the Human Development Index and the Wellbeing index were not appropriate for the purpose of the CRAF. Therefore specific uniform impacts indicators (scaled from 0 to 1) were designed to score the hotspots using a multi-criteria analysis approach. The INtegrated DisRUption Assessment model (henceforth INDRA) was specifically developed to assess these impacts and score the hotspots. To meet research and practical needs three techniques were considered in the model depending on available knowledge, data and resources and as such preferred to more complex modelling techniques: a susceptibility-based approach, a matrix-based approach and a network analysis approach.

One added value of the CRAF and its approach was the sustained effort to have a high level of stakeholder input in the development of the framework. Their role included supporting the collection of information for evaluating potential direct and indirect impacts, inputting in the multi-criteria analysis process, validating and selecting the hotspots. The CRAF also informs stakeholders on the data quality used for the assessment to support their decision, as well as an evaluation of necessary efforts in future data collection.

### 3.3 Enhanced quantitative early warning and scenario evaluation capabilities (WP3)

#### 3.3.1 Baseline

At the outset of the project, only a few member states had a coastal EWS in use for civil protection and most states did not include coastal flooding as a risk in civil protection schemes. The systems in place were typically hazard-oriented in nature, providing insight into the intensity of an event (i.e. exceedance of a water level) but not into its impacts and resilience to these impacts. Also, EWS were implemented on computer servers because of computational demand. This requires warnings and information on events to be distributed to decision makers in the field through ICT networks which have high vulnerability during extreme events. Also, because of the processing time required for computations, it is a challenge to include local observations and rapidly-changing information that becomes available towards the peak of an event.

The FP7 project MICORE showed the feasibility of including two-dimensional morphodynamic models into coastal EWS. However, MICORE focused on hazard intensity maps and did not include impacts. Also, that project showed that the robustness and flexibility of the coupling of hydro- and morphodynamical models remained a major challenge. Furthermore, existing coastal zone or flash flood EWS only concern one type of hazard (wind, water level, flash flood) and did not include multi-hazards impacting one system.

At the beginning of the project, robust flood EWS for river networks were operational (e.g. European Flood Alert System). The Delft-FEWS (Flood Early Warning System) for river basins was the most robust system available with implementation across Europe. Delft-FEWS prescribes a generic system, while allowing the use of local users' preferred model software.

#### 3.3.2 Planned progress beyond the state-of-the-art

Given this baseline, forecasting disastrous events in coastal areas will greatly improve if various hazards which affect the coastal zone such as surge-driven floods, coastal erosion, breaching, overtopping and rain-driven flash floods can be incorporated in EWS/DSS systems.

The first advancement of the project will be to expand the functionality of Delft-FEWS to coastal environments. In RISC-KIT we will develop a robust and flexible model coupling system for the computation of multi-hazard intensities in coastal environments. In a pilot project, Delft-FEWS was modified for a dedicated North Sea application using Deltares wave and surge models. This will be expanded to allow for any wave/surge model system.

The second advancement is to include morphodynamical and flash flood models. To the first aspect, the storm-response model XBeach will be incorporated in a 2D efficient mode and expanded in functionality. In order to compute rain-driven flash floods, the modules developed in DRIHM and IMPRINTS will be incorporated.

The third advancement is the distribution of EWS information to the field. The goal is to develop a means to supply decision-makers with a stand-alone EWS/DSS which uses information from ex-ante scenario computations and which can be updated with the latest available information. We will develop a Bayesian-based Decision Support



System which will connect hazard intensity and socio-economic, environmental and cultural distributions and thus allow the transition from hazards to impacts. A Bayesian-based network is a graphical model that describes complex system relations in probabilistic terms, and which can be run on a local PC or smart phone. Ex-ante, Bayesian networks allow the exploration of “what-if” scenarios in which the intensities of physical hazards can be varied and proposed DRR plans can be evaluated, stimulating dialogue between scientists, end-users and stakeholders. The key challenges in developing the DSS are i) properly implementing spatial relations between variable distributions (i.e. ripple effects), ii) Integrating quantitative hazard variables and qualitative social and cultural attributes, iii) optimizing the network for the required input data, and iv) developing a methodology to incorporate DRR plans developed in WP4.

### 3.3.3 Project advances

#### Application of Delft-FEWS to coastal environments

In answer to the first advancement a free-ware Coastal Early Warning System/Decision Support System (EWS/DSS) was developed. The Delft-FEWS (Flood Early Warning System) software, mainly used to support fluvial forecasting systems, was further developed for specific use in coastal applications. The following extensions were made to the software (Bogaard et al. 2017 forthcoming):

1. Import routines have been developed for CS3xTidalSurgeTime and MetOfficeWW3.
2. The Delft-FEWS Client has been improved related to coastal data visualization.
3. Model adapters have been developed specifically for the coastal models SelfeWWMII, Telemac, Xbeach, and Continuum.
4. The model adapters for Delft-3D and WaveWatch III have been extended.
5. In order to move towards impact based forecasting and to support decision making an adapter for the BN reasoning engine SMILE Netica as described in the previous section has been developed as well. As such, this model can now be included in the Early Warning framework.

All developed adapters are available as part of the Delft-FEWS software. In addition documentation has been made available on how to code a model adapter for any arbitrary model.

#### Morphodynamical and flash flood models

In answer to the second advancement the storm-response model XBeach as well as the flash flood model developed in the FP7 project IMPRINTS have been incorporated into the Delft-FEWS platform. In addition to these planned activities, supplementary work was carried out to improve physical processes in Xbeach (1), SWAN (2) and the flash flood model (3).

1. XBeach has been further developed to improve the computational speed of the model as well as the physical descriptions to enhance the accuracy and reliability. The developments are validated and tested for field situations and engineering applications.



2. A new formulation for estimating the wave energy dissipation over vegetation in coastal areas is implemented in SWAN model and validated against flume tests and field measurements.
3. The flash flood model developed in the FP7 project IMPRINTS is improved by increasing the resolution and better estimation of the hazard level. The improved model is applied successfully around the Tordera Delta Case Study in Spain and an implementation procedure is made available.

In answer to the third advancement a Bayesian-based Decision Support System (DSS) was developed to allow for the prediction of impacts resulting from coastal multi-hazards for various hot spot areas. The Bayesian Network DSS is a data driven model that describes system relations in probabilistic terms. Generally, Bayesian Networks are pre-fed with data from which they “learn” relationships and can then be used to predict or diagnose events. The DSS is based on data from hydrodynamic storm simulations, information on land use and so-called vulnerability relationships. The approach can easily be applied to any hot spot area. In an innovation, the Bayesian Network has been extended to include qualitative social and cultural attributes (Cumiskey et. al. 2017 forthcoming) and non-quantitative measures such as “education. Integrating quantitative hazard variables and

#### Web application connected to EWS/DSS

The Delft-FEWS based EWS including DSS is developed for forecasters and decision makers at expert level. Proper use of the system requires both expertise in underlying physical processes as well as basic knowledge of the EWS software. For local authorities, stakeholders and the general public, forecast and warning services need to be disseminated using products that are easy to interpret and access. For this reason, the additional effort was made to develop a web application.

This application can be assessed without connection to or experience with the Delft-FEWS software offering information in a way limited prior knowledge about the underlying physical processes is required (Bogaard, 2017). The web viewer contains three different types of information for each case study site: (1) Outcome of a risk assessment study (CRAF 1), (2) Onshore hazard information for a hot spot area identified in the risk assessment, (3) Coastal Impact based on Bayesian network results. Both the stand-alone EWS/DSS and the web application use information from ex-ante scenario computations and can be updated with the latest available information.

The improved physics-based models and new developments (source-codes) delivered in this task are made available through the open source and free software community web portal ([www.oss.deltares.nl](http://www.oss.deltares.nl)), with links from the RISC-KIT project website. The web application can be accessed at: <http://al-ng017.xtr.deltares.nl/riskkit/index.htm>

### **3.4 Integrated risk reduction and resilience plans (WP4)**

#### **3.4.1 Baseline**

The EU has outlined approaches for adapting to the impacts of climate change on Europe's coasts and RISC-KIT partners have been engaged in EU Member State and regional efforts to address these (perceived longer term) challenges. However, (short

term) DRR strategies to manage hydro-meteo impacts such as storm surges and coastal flooding from sea and land had seldom been developed in conjunction with climate adaptation plans. Given their shared aims of increasing resilience, there is a growing awareness of the need for integration between these two policy areas. Moreover, effective DRR measures need to be integrated with a range of existing policies e.g. for environmental and social protection and sustainable development as well as with local and national infrastructure.

### **3.4.2 Planned progress beyond the state-of-the-art**

RISC-KIT will address this need by developing combinations of DRR measures ('strategic alternatives') for the case study sites by linking to existing policy and decision-making processes and strengthening partnerships between relevant sectors and groups in local and regional communities.

In a first advancement, RISC-KIT will demonstrate practical ways in which the multi-hazards from the sea and the land can be integrated into DRR approaches. Thus, we will show how Integrated Coastal Zone Management (ICZM) and Integrated Water Resources Management (IWRM) can be linked with DRR strategies which go over and beyond the scope of the Flood Directive. Through this integration, RISC-KIT aims to encourage greater policy effectiveness and to increase coherence with existing systems, policies approaches and goals to ensure their sustainability and cost-effectiveness.

In a second advancement, risk reduction and resilience plans developed in RISC-KIT will constitute a tailor-made mix of DRR strategic alternatives, which will explicitly include adaptive management measures that move away from a worldview of preventing or avoiding risk, towards accepting risks. Therefore, apart from traditional hard-infrastructure technological solutions, the project will consider ecosystem-based solutions and ways of 'living with hazards'.

In a third advancement, as resilience to natural events is deeply rooted in social systems, local and community-level understandings of risk are acknowledged as legitimate descriptions of system dynamics. Thus, for effective DRR at an EU and international level, it is essential that lessons learned and user knowledge of local socio-economic, historic and cultural factors are shared between actors. To account for this, RISC-KIT will make use of participatory methods (live-polling, moderated discussion groups or roundtable discussions) that have been successfully applied in previous projects, but that – as progress beyond the state of the art - will be adapted to suit the study site-specific requirements. This approach will also help build ownership amongst coastal end-users and stakeholders and contribute to improved multi-level governance and institutional accountability.

Fourthly, acceptability of the plans will be improved by evaluating them against a range of climate scenarios at the case study sites, using an integrated assessment that as a progress-beyond-the-state-of-the-art combines a multi-criteria analysis and a soft systems methodology. The first will assess the technical and economic feasibility and the capacity to reduce disaster risk. The soft systems methodology takes different viewpoints of end-users and stakeholders into consideration.

### 3.4.3 Project advances

In answer to the first advancement potential prevention, mitigation and preparedness measures were developed following an integrated approach that took socio-economic, cultural and environmental issues and existing policies into account. The process began with a review of current local risk management and civil protection strategies at the case study sites from official documents. In addition, all case study site partners generated knowledge and data through stakeholder consultations involving key end-users with experience of managing disaster events or post-disaster assessment. These management experiences were complemented and contrasted with information from local citizens who witnessed these disasters first-hand. In this way, the main issues and possibly conflicting perceptions between groups were captured. As many of these approaches naturally link to issues of integrated coastal zone management and integrated water resources these topics were entangled in the potential prevention, mitigation and preparedness measures in one or the other form.

For the second advancement, it was expected that apart from hard-infrastructure and technological solutions, the project would find ways to integrate ecosystem-based solutions and ways of 'living with hazards'. Nevertheless, the measures (strategic alternatives) identified by stakeholders rarely included non-technical, ecosystem based approaches or ways of 'living with hazards' to DRR. A main hindering factor was the lack of practical evidence for the effectiveness of ecosystem based measures to meet safety requirements. Nevertheless, on the basis of secondary sources and reports from case study sites, but also by including knowledge and experience of coastal communities, coastal manager and other end-user such as daily experiences, observations and best practises, the team were able to identify some ecosystem based measures which were then published in the web-based management guide. Also some example of dealing with hazards were included in the web-based management guide. In addition and as new achievement which was not specified in the RISC-KIT project at its outset, a cost-effectiveness analysis on ecosystem based measures was carried out for the case study site in Portugal and disseminated through the web-based management guide. In a further and more detailed development of the guide cost-benefit analysis could be included on a case by case basis.

In answer to the third advancement a combination of interactive methods such as qualitative interviews, moderated group and roundtables discussions were undertaken in order to investigate resilience in different social systems and communities. These methods were chosen and applied according to the specific situation in each case study site focusing on its socio-cultural appropriateness and effectiveness of the methods in general. Prior to the consultation sessions, a protocol and internal training session was carried out specifically for each case study site explaining to case study site partners the methods and procedures to be used. In addition, and where appropriate, archival material and personal stories e.g. from earlier historical events were included in the research. Based on these activities a set of locally tailored measures or combinations of measures (strategic alternatives) were identified for each case study site through close interaction with study site partners and local end-users. The strategic alternatives focused on site-specific hazards and measures which took technical and non-technical measures and societal perspectives and needs into account. The information was gathered alongside the interview

processes and at the end-user day. The identified measures and strategic alternatives were tested against a range of climate scenarios at the case study sites.

In answer to the fourth advancement and based on the results of these scenario simulations the proposed measures and strategic alternatives for each case study were then evaluated using a Multi-criteria Analysis tool (Chapter 2.5). Through this process, the technical and economic feasibility and the capacity to reduce disaster risk were assessed. The Multi-criteria Analysis took different viewpoints of end-users and stakeholders into consideration and evaluated social, cultural and political feasibility of proposed measures (strategic alternatives) through moderated consultation sessions. All in all, the process had a much more inclusive and interdisciplinary process than was foreseen, with positive outcomes for communication and rapport-building.

A Web-based Management Guide (Chapter 2.3) was produced to facilitate EU-wide learning and exchange for the development of risk reduction measures (strategic alternatives). Prior to its development other web guides were analyzed and discussed with end-users at the RISC-KIT end user day in Brussels in October 2015 regarding their preferences and necessities.

The guide is published in the form of an open-access webpage and highlights key principles recommended for the design and implementation of local DRR measures (strategic alternatives) using examples from the RISC-KIT case studies and elsewhere to provide practical illustrations to coastal managers in Europe. The guide includes prevention, mitigation and preparedness measures with recommendations for their use in various socio-economic, cultural and environmental settings. The Guide was intended to make recommendations about cost-effectiveness, and the development of timelines for decision-making. However, over the course of end-user consultations, it became clear that recommendations needed to be local and context specific. For this reason, the guide focused on providing general information about DRR measures and specific examples from which users could draw inspiration for their local context, rather than presenting one-size-fits-all recommendations. The Multi-criteria Analysis tool is detailed in the Guide and is recommended as an effective method for local stakeholder involvement through which to distinguish realistic and effective strategies over the short and long-term. These points are elaborates within the single strategic alternatives and can vary to certain degrees as knowledge and information is not equally available across all points. The web-guide was developed in a much more participatory way than planned, and end-users and case study owners (consortium members responsible for particular case study sites) were consulted with ensure the usefulness and uptake of the web-based guide. Furthermore, although the web-based management guide is embedded in the main RISC-KIT website, the team created a standalone product. The resulting website has a graphical and user-friendly interface with an expansive underlying information base.

### **3.5 Dissemination, knowledge transfer and exploitation (WP6)**

This part of the project was dedicated to engaging third parties. At the outset of the project we aimed to identify 391 key end-users and stakeholders for the case study areas to be engaged in interactive dialogues. These groups covered the countries

involved in the RISC-KIT project (either as partners or case study sites) and were primarily from the national and local level (102 and 89, respectively).

A dissemination strategy laid out the use of different communication tools to be used to engage these third parties in the project. Different tools used included the RISC-KIT website, social media (Facebook, LinkedIn and Twitter) and through periodic RISC-KIT newsletters (total subscriptions as of February 2017: 900). The project brochure was also distributed at different international meetings by all partners. The website was the main hub of the project where new visitors were encouraged to sign up to the project newsletter.

The RISC-KIT website serves as a hub for all project-related information and resources including project results and outputs. A key component of this is the RISC-KIT tools themselves. Five tools in total were developed during the course of the project and all of these tools are publicly available and free to download via the project website: [www.risckit.eu](http://www.risckit.eu).

Two promotional films were also developed within the scope of the RISC-KIT Dissemination strategy. The first of these, an animated movie, was developed by partners at Ecologic Institute. The animated movie described the tools and their applications for a non-specialist audience. The second film was a testimonial to the tools themselves and featured contributions by end-users and the tool developers outlining the practical importance of the RISC-KIT tools. These films, as well as many others including presentations, interviews with the RISC-KIT International Expert Board and participants in end-user days, are available on the RISC-KIT YouTube channel.

Three dedicated end-user days were organised to maximise end-user engagement tools through their involvement in different stages of tool development:

1. End-user Day 1: Bologna, IT (November 2014): feedback on preliminary versions of the tools, focus on type of data available, sharing personal experiences of extreme weather events at the case study sites.
2. End-user Day 2: Brussels, BE (October 2015): feedback on latest tool developments, web-based management guide, graphical user interfaces, presentations by end-users, theory and practice sessions to encourage dialogue and contributions from participants.
3. End-user Day 3: Delft, NL (April 2017): sharing of experiences from end-user perspectives, presentations from case studies and demonstrations of final RISC-KIT toolkit.

The Feedback from each of these events was very positive and participants generally remained engaged with the project afterwards, maintaining contact with the case study owners (consortium members responsible for particular case study sites) and attending other workshops and/or events. While the total number of participants in the RISC-KIT end-user days was not extensive, usually one end user per case study, key practitioners from almost all case study sites were present on most occasions.

Two RISC-KIT Summer Schools, one held in Ferrara, Italy in 2016, the other held in Faro, Portugal in 2017, invited students from all over Europe and beyond to come together and learn about the RISC-KIT tools. The courses were disseminated through a wide range of topical mailing lists and via RISC-KIT social media and online outlets,

attracting 132 applicants in total. Places were offered to 20 students on each course: with 19 participants and 18 participants attending the first and second Summer Schools, respectively. The first Summer School focused on the Storm Impact Database, the CRAF tool and the Web-based Management Guide, in the context of the case study site Porto Garibaldi/Bellocchio. The second Summer School covered the set-up of the Hotspot Tool, incorporating the Early Warning System and Bayesian Network for Decision Support, in the context of the case study site Praia de Faro. Feedback from the students was very positive in terms of the content and quality of both summer schools. As an additional benefit to the coastal DRR community of practice, the material covered in the Summer Schools was converted into two e-learning modules. The modules include tutorials, selected reading materials and a self-assessment exercise to encourage independent learning about the RISC-KIT tools. All E-learning modules are publically available via the RISC-KIT website.

Building gender-balanced capacity on coastal zone resilience was an explicit goal of the project and was prioritised during the workshops and summer schools. The ratios (female: male) of each of the outreach events was as follows: End User Day 1 (3:4), End User Day 2 (6:7), End User Day 3 (5:7, expected at time of writing in March 2017), Summer School 1 (10:9), and Summer School 2 (8:10).

A particularly important element of the RISC-KIT Dissemination strategy involved the publication of a series of peer-reviewed scientific contributions in a special edition of the international journal Coastal Engineering due for publication in October 2017. In total, 23 papers, covering technical aspects of the tools, their application to case study sites and other research outcomes of the project were selected for this special issue. All members of the consortium contributed to dissemination and communication activities through participation in scientific conferences, publication of papers in international peer-reviewed journals (in addition to the Coastal Engineering Special Issue), giving presentations to different audiences of citizens, decision makers and through radio and television interviews, through articles in the popular media. For more information on the different dissemination products, see project Deliverable 6.4.



## 4 Ongoing policy processes at EU and international level

The insights from Chapters 2 and 3 demonstrate that efforts to increase coastal resilience must be embedded in the local context. At the same time, it is essential to address risk governance from a multi-level perspective from local to regional, national and supra-national levels. In the following chapter we thus turn our attention to macro-level policy processes at EU and international level. We examine not only how flood policies (e.g. EU Floods Directive) and disaster risk reduction frameworks (e.g. UNISDR Sendai Framework 2015-2020) support coastal DRR and resilience; we also highlight the cross-cutting relevance of other initiatives e.g. for climate adaptation, biodiversity and sustainable development. The aim of this chapter is to provide a broader context for our lessons learned and recommendations in Chapter 5 and to ensure that they are aligned with the relevant processes.

### 4.1 EU level

This chapter provides background to ongoing macro-level initiatives at EU and international level that are of relevance to coastal DRR.

The Floods Directive (FD) 2007/60/EC is the European legislation for managing flood risk from floods of all flood types (fluvial, pluvial, sea water, groundwater, artificial water bearing infrastructure). From 2007 – 2015, Member States were asked to produce Preliminary Flood Risk Assessments, Hazard and Risk Maps and Flood Risk Management Plans.

At the time of writing (March 2017) a draft report on “Flood Risk Management in the EU and the Floods Directive’s 1st Cycle of Implementation (2009-15)” is underway, based on Member States’ responses to questionnaires.<sup>2</sup> Although this is still in draft form, the report already highlights obstacles and challenges found by Member States in the implementation of the FD that are corroborated by the findings of the RISC-KIT project. This includes, in particular, the need to produce high quality, consistent national receptor datasets for the assessment of flood impacts on infrastructural assets and especially social and cultural assets. In addition, the observation made during the project that low uptake of ecosystem based approaches to coastal DRR may be due to a lack of evidence base is reflected in the questionnaire; Member States expressed the need for guidance on the assessment of the effects of non-structural measures and natural water retention measures on flood risk.

Some of the challenges identified by Member States in the first implementation cycle of the FD can be directly addressed by the tools developed in the RISC-KIT project. In Table 4.1 we list some of the needs highlighted by Member States to which RISC-KIT can make a useful contribution.

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<sup>2</sup> [https://circabc.europa.eu/sd/a/8768cbc2-85f3-428f-b859-f9aee7a27e56/FD%201st%20cycle%20questionnaire%20report\\_formatted\\_07%20March%202017.pdf](https://circabc.europa.eu/sd/a/8768cbc2-85f3-428f-b859-f9aee7a27e56/FD%201st%20cycle%20questionnaire%20report_formatted_07%20March%202017.pdf)

*Table 4.1: RISC-KIT support to challenges identified by Member States in the first implementation cycle of the Floods Directive*

Need expressed by Member State(s)	How RISC-KIT supports this need:
<ul style="list-style-type: none"> <li>Improved information on significant historical floods and the impact that they have had (e.g. in terms of damage) from local sources. A centralised database for registration of flood events and the damage that they have caused. <sup>3</sup></li> </ul>	RISC-KIT produced a Storm Impact Database (Chapter 1.2) that collates physical, socio-economic, cultural and environmental information on historic coastal flood events. It provides a centralised framework for data collection and reporting and is open source. The tool is not only the only database to provide rich detail of historical coastal floods, it also improves on the fact that the majority of existing historical databases (on floods in general) are not publicly available.
<ul style="list-style-type: none"> <li>Develop new tools for the analysis of flood risks and facilitate more comprehensive assessment of risks to be able to develop higher-precision modeling based flood hazard and flood risk maps for the 2nd implementation phase. <sup>4</sup></li> </ul>	The Coastal Risk Assessment Framework (CRAF) (Chapter 2.2) enables analysis of coastal flood risk at two levels: firstly through an initial framework that is simple to use, quick to apply, with high accuracy and can assess current state and evolution of coastal risk; and secondly through an additional framework that is robust, uniform, adaptable to local realities, and superior to expert judgement alone.
<ul style="list-style-type: none"> <li>Production of a catalogue of measures<sup>5</sup></li> </ul>	The Web-based Management guide (Chapter 2.3) provides information about a range of measures (including prevention, mitigation and preparedness, structural and non-structural, grey, green and combined approaches) that can be implemented for coastal flood DRR.
<ul style="list-style-type: none"> <li>Improve information on coastal</li> </ul>	The Hotspot (Early Warning

<sup>3</sup> This need was expressed in 3.27, pg. 80 of [Flood Risk Management in the EU and the Floods Directive's 1st Cycle of Implementation \(2009 -15\): A questionnaire based report](#)

<sup>4</sup> These needs were expressed in 4.1, "Main challenges that affected flood hazard and risk mapping", pg. 92 of [Flood Risk Management in the EU and the Floods Directive's 1st Cycle of Implementation \(2009 -15\): A questionnaire based report](#).

<sup>5</sup> This need was expressed in 1.7, "The need for further guidance", pg. 22 of [Flood Risk Management in the EU and the Floods Directive's 1st Cycle of Implementation \(2009 -15\): A questionnaire based report](#).

floods <ul style="list-style-type: none"> <li>• Increase local government involvement in flood forecasting and early warning system and self-monitoring<sup>6</sup></li> </ul>	System/Decision Support System (EWS/DSS)) (Chapter 2.4) extends flood EWS to include coastal floods and is able to assess multiple hazards for their relative intensities and impacts and its generic configuration means that it can be adapted for use with existing local systems and software.
<ul style="list-style-type: none"> <li>• More emphasis on active involvement of various stakeholders in flood risk management, and to increase public involvement and acceptance<sup>7</sup></li> <li>• Prioritisation of measures<sup>8</sup></li> </ul>	The Multi-criteria Analysis tool (Chapter 2.5) provides a method for stakeholder engagement and interaction between civil society and government, cross-sectoral cooperation, and raises awareness of risk and allows for possible measures and plans to be discussed and prioritised.

Other processes at EU level that are relevant to coastal DRR include:

- The 2013 EU Climate Change Adaptation Strategy (COM/2013/ 216) sets out a framework for increasing European resilience in response to current and future climate impacts. The Strategy stresses that coastal zones are particularly vulnerable regions given the risks of sea-level rise and extreme weather events. The Strategy also recommends that Member States develop, review and implement adaptation plans to be in synergy with existing disaster risk management policies.
- Policies such as the Marine Strategy Framework Directive (2008/56/EC) and the EU Biodiversity Strategy (COM/2011/244) also contribute indirectly to coastal DRR, as they aim to support healthy ecosystems which in turn assist prevention, protection and mitigation strategies.
- The European Commission's Research and Innovation policy agenda for Nature-Based Solutions and Re-Naturing Cities<sup>9</sup> whose aim is to provide a supportive framework for building the evidence and knowledge base for nature-based solutions. The agenda is implemented, *inter alia*, through the Horizon 2020 Framework Programme for Research and Innovation.

<sup>6</sup> These needs were expressed in 1.3, "Improvements to the implementation of the Floods Directive", pg. 14 [of Flood Risk Management in the EU and the Floods Directive's 1st Cycle of Implementation \(2009 - 15\): A questionnaire based report](#).

<sup>7</sup> This need was expressed in 1.3, "Improvements to the implementation of the Floods Directive", pg. 13 [of Flood Risk Management in the EU and the Floods Directive's 1st Cycle of Implementation \(2009 - 15\): A questionnaire based report](#).

<sup>8</sup> The need was expressed in 1.2, "Obstacles to implementing the Floods Directive", pg. 12 [of Flood Risk Management in the EU and the Floods Directive's 1st Cycle of Implementation \(2009 - 15\): A questionnaire based report](#).

<sup>9</sup> More information: <https://ec.europa.eu/research/environment/index.cfm?pg=nbs>

- The EU Recommendation on Integrated Coastal Zone Management (2002/413/EC) and the Directive on Maritime Spatial Planning (2014/89/EU) both target the optimal distribution of the coastal and maritime space among various stakeholders and uses. This includes, for example the effects of infrastructure works to protect coastlines against erosion or flooding on activities in coastal waters such as aquaculture or protection of marine ecosystems.
- The EU Civil Protection Mechanism (1313/2013/EU) sets the framework for a holistic, cross-sectoral disaster risk management policy for the Union. This is to be achieved by promoting a culture of preparedness, replacing ad-hoc response with a pre-planned approach, and supporting Member States in their capacities. It does so through training, learning and exchange (governance, planning, data, risk communication and information, research and technology) information sharing (Common Emergency and Information System (CECIS)) and mechanisms for coordinated preparedness and response at EU level such as the European Emergency Response Capacity (EERC) established in 2014.
- The Post 2015 Hyogo Framework for Action: Managing risks to achieve resilience (SWD /2014/133) analyses EU progress under the UNISDR Hyogo Framework for Action and addresses implementation gaps and emerging challenges. Some of these findings are of particular relevance to the RISC-KIT project. The Communication notes *inter alia* the need for:
  - particular attention to building resilience in coastal areas;
  - collection and sharing of sound and comparable data on disaster losses, hazard and vulnerability in an open data policy;
  - development of common and interoperable data and risk assessment protocols and public risk registers and databases;
  - systematic actions to raise public awareness of risk;
  - build sustainable partnerships between different public authorities and relevant stakeholders (civil society, academia and research institutions, private sector) and involve these actors in decision-making processes through inclusive participatory mechanisms.
- The European Structural and Investment Funds (ESIF) directly contribute to Sendai Framework Priority 3: Investing in disaster risk reduction for resilience. The ESIF have helped promote disaster risk management, climate change adaptation, ecosystem conservation and cultural heritage restoration in EU policy. The Funds include a thematic objective on “Climate change adaptation and risk prevention and management”, to which Member States have allocated over 29 billion EUR. Disaster resilience and risk prevention and management are promoted horizontally in all other priorities, which amount to more than EUR 454 billion of EU co-financing. Climate and disaster proofing is built into the appraisal of major projects for cohesion policy support, and is a prominent topic in macro-regional strategies, such as for the Danube and Baltic Sea Regions.

- The INSPIRE Directive came into force in 2007 and will be implemented in various stages, with full implementation required by 2021. It aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies. INSPIRE mainly recommend recording information for the direct impact assessment. RISC-KIT agrees with these efforts but recommends recording additional information as specified in Chapter 5.2.

The RISC-KIT project contributed to these EU level processes through the development of tools and good case DRR measures and management practices captured in the web-based management guide. Both tools and measures were informed by a holistic approach embedding the above described policies and hence contribute to the reduction of risks and increase of resilience to low-frequency, high-impact hydro-meteorological events in the coastal zones.

## 4.2 International level

The RISC-KIT project was conceived in 2013, during the final phase of the UNISDR Hyogo Framework for Action (HFA) (2010-2015). Although the HFA has since been replaced by the Sendai Framework (2015-2020), the new Framework confirms the relevance of the RISC-KIT approach and methodology as well as the project's findings. Specifically, the project's research approach is aligned with the following Sendai Framework 'Guiding Principles' (§19):

- (d) Engagement from all of society;
- (g) Decision-making to be inclusive and risk-informed while using a multi-hazard approach;
- (i) Accounting of local and specific characteristics of disaster risks when determining measures to reduce risk.

Furthermore, the RISC-KIT tools and activities contribute directly to the achievement of Priority 1 "Understanding disaster risk" by offering information; Priority 2 "Strengthening disaster risk governance" by presenting management strategies ; and Priority 4 "Enhancing disaster preparedness for effective response" by providing tools and measures and management strategies . (Detailed evidence of these contributions is provided throughout Chapter 5).

However, the Sendai Framework is not the only international agenda to which the RISC-KIT approach and project findings are able to support. Here we outline some other international processes which are of relevance to coastal DRR and to which the RISC-KIT tools and outputs can make a positive contribution.

- Article 8 on loss and damage in the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement outlines areas for cooperation between the Contracting Parties, including on: early warning systems, emergency preparedness, events that involve irreversible damage, comprehensive risk assessment and management.
- Sustainable Development Goal 11 (Make cities inclusive, safe, resilient and sustainable) includes Target 11B which seeks to, by 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource

efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels as well as Sustainable Development Goal 13 (Take urgent action to combat climate change and its impacts).

- The Convention on Biodiversity COP 12 Decision XII/20 acknowledges the significant role that conservation and sustainable use of biodiversity and the restoration of ecosystems can play in disaster risk reduction, and encourages Parties to promote and implement ecosystem-based approaches to disaster risk reduction, in both terrestrial and marine environments, and to integrate these into their policies and programmes, as appropriate, in the context of the Hyogo Framework for Action 2005–2015. The Decision also requests the Executive Secretary to compile and analyse, in cooperation with relevant organizations, including the United Nations Office for Disaster Risk Reduction, the World Meteorological Organization, and the International Union for Conservation of Nature information on ecosystem-based approaches to disaster risk reduction and to compile experiences with ecosystem-based approaches to climate change adaptation and disaster risk reduction and to share them through the clearing-house mechanism.

We now move to examine the lessons learned and recommendations resulting from the RISC-KIT project, with consideration of how these can be aligned with the policies described in Chapter 4.



## 5 Lessons learned and recommendations

In the following chapter, we highlight the achievements, lessons learned and challenges identified through the development and application of the RISC-KIT tools (Chapter 2) other project activities (Chapter 3). These lessons are drawn above all from the work carried out at the local level in ten case study sites. However, wherever possible, these are considered in relation to their relevance to EU and international processes (as outlined in Chapter 4), thus emphasising the multi-level dimensions of risk governance. As the key international framework for DRR, the UNISDR Sendai Framework 2015-2020 is paid particular attention. The lessons learned are fed into a series of recommendations developed by the project consortium for improved DRR for Europe and beyond. Some of these recommendations are of a practical nature (e.g. relevant to those responsible for the selection of coastal DRR measures); others of a broader nature (relevant to those able to affect policies for improved DRR). Care has been taken to ensure that the recommendations are rooted in the evidence and experiences of the project.

One of the key lessons of the project is the need for flexibility e.g. by developing generic rather than specific tools that can be adapted to local conditions. Furthermore, coastal risks must be addressed on the understanding that each coastal area has a unique set of environmental, socio-economic, and cultural characteristics, and that in the future, these conditions may shift in different ways according to climatic and other changes within regions and states as well as in transboundary contexts. Although an initial goal of the Synthesis Report was to make recommendations in alignment with existing national policies, our research shows that approaches to coastal DRR vary substantially across Europe. For this reason, it was seen as both unfeasible to make different recommendations for each Member State, and also inappropriate to make a set of global recommendations equally applicable to all national European contexts. Thus while we indicate 'who should act', the recommendations are not tailored to specific countries or groups with the expectation that this will shift according to context.

### 5.1 Lessons learned on: Hazard and impact assessments and data

The RISC-KIT project progressed from analysing single hazards to multiple hazards, and from assessing direct impacts to indirect impacts, systemic disruptions and recovery, because an impact-based approach is crucial to risk reduction decision-making. Understanding where and how these multiple hazards will likely affect social and economic systems and infrastructure in coastal areas enables a more intelligent and cost-effective selection of DRR measures and emergency management. The Sendai Framework likewise refers to the need to assess and anticipate the potential economic and social impacts of disasters (§31 (d)).

In addition and in line with the INSPIRE Directive RISC-KIT fully supports European efforts on spatial data collection but recommends in addition recording information

on the indirect impacts and on the recovery time as well as having both quantitative and descriptive information.

However, our research shows that European Early Warning Systems are thus far still focused on hazard forecasting. The RISC-KIT Bayesian-based Decision Support System (DSS) is an effective tool for predicting impacts resulting from coastal multi-hazards for various hot spot areas. Nevertheless, the ability of the project team to determine the potential consequences - and therefore adequate responses - was constrained by the lack of adequate and standardised vulnerability and impact data in the EU Member States that were analysed. The European Commission already pointed to this issue in 2013 in its Post 2015 Hyogo Framework for Action: Managing risks to achieve resilience (SWD /2014/133) which supports the collection and sharing of sound and comparable data on disaster losses, hazard and vulnerability in an open data policy. In addition protocols should be established for each member state allowing post surveying of storms in a unified matter.

All tool applications have shown a need for spatially-accurate and up-to-date topographic, physical, and impact data (e.g. on vulnerability or socio-economic impacts) using uniform standards. Priority 1 of the Sendai Framework also points to the need to systematically evaluate, record, share, and publicly account for disaster losses and understand the economic, social, health, education, environmental and cultural heritage impacts, as appropriate, in the context of event-specific hazard-exposure and vulnerability information (§24 (d)). One of the advances of the RISC-KIT project was the collection of such data in a Coastal Storm Impact Database (See Chapter 2.1). The Database is the first of its kind in Europe, providing an overview of events from the present day, stretching back to the year 1304. However, the data collection process presented some challenges. While some of the older storms were recorded in particularly rich detail (e.g. the storms hitting the coast of Eastern England, the Algarve coast in the early 20th century etc), there is a lack of publicly available information – in particular for the more recent, 20<sup>th</sup> – 21<sup>st</sup>

RISC-KIT recommendation on impact based approach

*"Promote the development and use of impact-based assessments and early warning systems and decision support systems"*

Who should act? EU member states, national and regional administrations, coastal managers.

RISC-KIT recommendation on data (i)

*"Build the knowledge base on coastal flood impacts in Europe through historical research and standardised protocols for post-event recording with awareness-raising on the need for such information."*

Who should act? EU and EU Member States to provide framework; implementation by local administrations.

RISC-KIT recommendation on data (ii)

*"Establish protocols and systems to compile standardised EU datasets that allow for better understanding and prediction of impacts."*

Who should act? EU Member States.

century - impacts of coastal storm events. On the basis of our research three main reasons came to light for this lack of data: 1) a lack of standardised data collection procedures and protocols for immediate post-event recording of coastal storm surge impacts; 2) data exists but is publicly unavailable; and 3) lack of understanding of the purpose and type of data collection to be carried out. For the most part, the RISC-KIT research team was able to overcome this lack of information through personal contacts and direct requests for information. However, the process of gathering this data was labour intensive – with additional effort, systems can be established to facilitate the process of building up the Storm Impact Database so that it becomes a content-rich resource for disaster risk reduction efforts e.g. through the EUs Civil Protection Mechanism (1313/2013/EU). The experiences of the RISC-KIT project on this point are also supported by the European Commission in its Post 2015 Hyogo Framework for Action: Managing risks to achieve resilience (SWD /2014/133) which notes the need for developing common and interoperable data and risk assessment protocols and public risk registers and databases.

## 5.2 Lessons learned on: Tool development and the need for validation of data

RISC-KIT has developed a generic suite of tools which make a significant contribution to coastal DRR in Europe and beyond. These provide contributions to the Sendai Framework's Priorities 1, 2 and 4 but ensured that these were flexible enough to be adapted to local circumstances. Within RISC-KIT two main tools types have been developed: informative (Storm Database and Web-based Management Guide) and assessment (CRAF, Hotspot Tool, Multi-Criteria Analysis) tools (see Chapter 2). The first two have been fully developed and are ready to use, needing however a continuity of information upload (see Technology Readiness Levels, Table 2.7). The lessons learned with the Storm Database have been already discussed in Chapter 2.1 while for the Web-based Management Guide they have been discussed in Chapter 2.3. The lessons learned with the MCA application have also been discussed in Chapter 2.5. Here, the CRAF and the Hotspot tool (EWS/DSS) will be further analysed.

The application of the above tools in ten different case study sites demonstrated their robustness and wide applicability. Indeed, the CRAF (Chapter 2.2) has already been applied beyond the case study areas. This application is both in Europe (the Cadiz coastal area and Denmark) and beyond: the RISC-KIT project partner IMDC applied Phase 1 of the CRAF to identify and rank possible hotspots along the coasts of Ivory Coast, Ghana, Togo and Benin in West Africa.<sup>10</sup>

RISC-KIT recommendation on tool development (i)

*"Promote the application of coastal risk information and assessment tools to optimise resources to be spent on coastal risk management."*

Who should act? EU member states, national and regional administrations, coastal managers, academic community, consultants.

<sup>10</sup> The application has been undertaken as part of the study "Cost of Coastal Environmental Degradation, Multi Hazard Risk Assessment and Cost Benefit Analysis" within the World Bank WACA Technical

The further application of such tools on the scale of large coastal areas will permit the identification and ranking of coastal risk hotspots and the optimisation of resources by identifying priorities of action for each coastal hazard. The implementation of such a tool can, thus, provide a clear vision on what are the expected risks and their potential indirect effects at a regional scale, promoting a vision for needs on coastal management for the next decades as well as an optimisation of resources to be spent.

The developed Hotspot Tool (Chapter 2.4) consists of an Early Warning System coupled with a Decision Support System that allows the prediction of potential risks and onshore impacts associated with a storm, as well as an ex-ante assessment tool of measures to minimise the identified risks. The Sendai Framework notes the need to assess and anticipate the potential economic and social impacts of disasters (§31 (d)). However this focus on *impacts*, rather than the *hazards* is new. The use of such a tool is currently still uncommon, not only in Europe but also worldwide. Without doubt, this tool will be required in the near future to minimise the exposure of coastal populations to the already existing hazard, but also to its potential increase in association to changes in storminess and sea level rise. It can therefore be expected that there will be a palpable necessity for such tools, and their systematic application in risk management, in the near future. To ensure this demand is met, policies must be geared towards assisting further developments and implementation of such tools, namely in order to bring it to the level of knowledge of the coastal managers, civil protection or any other stakeholders that will be responsible for its day-to-day use.

RISC-KIT recommendation on tool development (ii)

*"Promote the development and use of impact-oriented early warning systems and decision support systems (e.g. RISC-KIT EWS/DSS tool) to facilitate evidence-based decision-making in emergency management and coastal DRR management (e.g. through better assessment of protection, mitigation and adaptation measures).*

Who should act? EU member states, national and regional administrations, coastal managers, academic community, consultants.

### 5.3 Lessons learned on: Coastal risk governance

Through in-depth analysis of 10 European case study sites and their governance structures, the RISC-KIT project has revealed a broad range of approaches to European DRR and coastal management. Despite these differences, some common challenges have become evident. These relate primarily to the need for clarity in governance structures and procedures; as well as the importance of citizen engagement, both in terms of providing local knowledge and in terms of awareness-raising for effective coastal DRR responses.

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Assistance program. More information can be found here: <http://www.imdc.be/news/cost-coastal-environmental-degradation-multi-hazard-risk-assessment-and-cost-benefit-analysis-%E2%80%93>

In some cases, there is a clear distribution of responsibility for coastal protection and disaster risk reduction (e.g. Varna, BG; Kieler Fjord, DE; Zeebrugge, BE; Kristianstad, SE). Despite this, corresponding levels of funding for local implementation are not always forthcoming (e.g. Varna, BG; Kristianstad, SE) which can create a tension between responsibility and capacity to act. Priority 3 of the Sendai Framework (§30 (a)) also directly addresses this issue, pointing to the need to allocate the necessary financial and logistical resources at all levels of administration. In the two Italian case study sites (Porto Garibaldi and Bocca di Magra, IT), overlapping competences e.g. between national and local authorities or coastal protection and flood risk management authorities were seen to pose a challenge. Examples such as England's Coastal Concordat<sup>11</sup> and EU level initiatives (e.g. EU Recommendation on Integrated Coastal Zone Management (2002/413/EC) and the Directive on Maritime Spatial Planning (2014/89/EU)) provide frameworks for the use of spatial planning and integrated management for an optimal coordination in the coastal zone.

In many of the case studies, low levels of civic engagement and limited public trust in authorities were highlighted (e.g. Ria Formosa, PT; Bocca di Magra, IT; Tordera Delta, ES; La Faute-sur-Mer, FR) which can negatively affect local capacity to prepare for and respond to storm events. The need for stakeholder engagement and an 'all-of -society' approach has already been mentioned above. The RISC-KIT project has provided open source tools with publicly available information on risks and DRR strategies and measures which can be used as a basis for open discussion. Furthermore, the Multi-criteria Analysis tool (Chapter 2.5) demonstrated an effective method for opening up communicative processes of information exchange which can further build civic engagement and trust. In this way, the project contributes to the implementation of the Floods Directive, by supporting the involvement of interested parties (§9) and by addressing Member State needs for the second cycle of implementation (see Chapter 4.1).

RISC-KIT recommendation on coastal risk governance (i)

*"Find ways in which authorities and/or competences can be streamlined to reduce overlap (e.g. England's Coastal Concordat) and ensure that local authorities have adequate financial and logistical resources to act."*

Who should act? National, regional and municipal administrations.

RISC-KIT recommendation on coastal risk governance (ii)

*"Engage citizens in participatory processes (e.g. through RISC-KIT Multi-criteria Analysis tool) and use open source information on coastal risks and disaster reduction strategies to inform discussions and build a culture of communication and trust"*

Who should act? Local administration and coastal managers; academic community, consultants.

<sup>11</sup> See <https://www.gov.uk/government/publications/a-coastal-concordat-for-england> for more information



## 5.4 Lessons learned on: Multi-disciplinarity

The Sendai Framework made a series of reflections on the implementation of the HFA. One conclusion was on the need for closer collaboration between public and private sectors and civil society organizations, as well as academia and scientific and research institutions.

RISC-KIT contributes to this through the make-up of its consortium and research methods that have sought to engage with a wide range of stakeholders.

In order to meet the project's objectives, it was necessary to have a multidisciplinary research team to collect and analyse qualitative and quantitative data. An open-learning process that involved staying over at the different case study sites, informal meetings with stakeholders and open-ended agendas was coupled with training and support to apply unfamiliar methodologies from disciplines other than their own. For example, engineers and modellers collected information on knowledge, values, behaviour and perceptions of risk, while social scientists were responsible for demonstrating the Early Warning System and Decision Support System tool to stakeholders. This integration of knowledge systems furthermore contributes to the Sendai Framework (§24 (h)) which highlights the need to promote and improve dialogue and cooperation among scientific and technological communities. The openness of the consortium members to experiment outside their 'comfort zone' was essential to building a more integrated and nuanced understanding of coastal disaster risk reduction within the team, and led to interdisciplinary initiatives within the project e.g. to incorporate qualitative interview data into the Bayesian Model. The development of the RISC-KIT tools was only possible with a project team consisting of engineers, modellers, economists, historians, anthropologists, and social scientists, all undertaking and applying multi-disciplinary research methods and learning from each other. This important aspect was central in the two Summer Schools for Young Scientists.

RISC-KIT recommendation on multi-disciplinarity

*"Facilitate multi- and inter-disciplinary approaches by providing colleagues with dedicated support and practical guides to accompany the process, including dedicated translators and data processing staff where necessary."*

Who should act? National and international research consortia and funding bodies.

## 5.5 Lessons learned on: DRR measures

In some RISC-KIT case study areas, single, standalone DRR measures did not provide adequate risk reduction. In the Swedish case study for example (Barquet et al., 2017 forthcoming) the combination of two DRR measures (in this case dune nourishment and flood proofing of homes) was the preferred solution. Similar experiences were made evident in other RISC-KIT case studies (see for example Plomaritis, et al., 2017 forthcoming). In particular, the combination of prevention with mitigation measures received high evaluation scores in the RISC-KIT Multi-criteria Analysis workshops (see Chapter 2.5.2). On this basis, the project adapted its approach to assessment of measures to what were termed 'Strategic Alternatives' (combinations of two or more DRR measures). This practical information from the project provides



support to the Sendai Framework (§25 (e)) as well as the EUs Civil Protection Mechanism (1313/2013/EU) for the exchange of information on lessons learned on measures for disaster risk reduction.

Ecosystem-based solutions (EBS), which are inspired and supported by nature and bring nature and natural features and processes into land- and seascapes, were discussed and presented to RISC-KIT end-users alongside other DRR measures. However at the local level in the RISC-KIT case studies, EBS were seldom selected and taken up, and only addressed in a few sites. Through discussions with RISC-KIT end-users two main causes for this were identified: 1) a lack of clear evidence that EBS can be as effective as traditional DRR measures; 2) EBS generally require more physical space than traditional structural DRR measures. For coastal cities in particular, space is often a limited resource (e.g. in the Italian Mediterranean) meaning that EBS approaches might be difficult to implement. One way to overcome this barrier can be to integrate EBS approaches in planned or existing structural prevention measures. The Convention on Biodiversity (CBD) COP 12 Decision XII/20 supports this notion, requesting the Executive Secretary to compile and analyse information on ecosystem-based approaches to disaster risk reduction and to compile experiences with ecosystem-based approaches to disaster risk reduction and to share them through the clearing-house mechanism. Building on DRR research under the FP7 on Research and Innovation, the European Commission is also pursuing a “Research and Innovation policy agenda for Nature-Based Solutions”.<sup>12</sup> The aim of this agenda is to provide the evidence and knowledge base for nature-based

RISC-KIT recommendation on DRR measures (i)

*“When planning DRR, consider that combinations of measures, especially prevention and mitigation, can be preferable to standalone measures and try to include ecosystem-based solutions. (see recommendation (ii) on DRR measures).”*

Who should act? Coastal managers at local level; academic community, consultants.

RISC-KIT recommendation on DRR measures (ii)

*“Build an evidence base with practical examples of how ecosystem based solutions can be an effective alternative to traditional DRR measures. Further, demonstrate how these approaches can be combined with, or integrated into, existing structural prevention measures (see recommendation (i) on DRR measures).”*

Who should act? Coastal managers at local level; academic community, consultants.

RISC-KIT recommendation on DRR measures (iii)

*“DRR and climate adaptation measures often overlap: to ensure synergies rather than doubling of effort, make these cross-overs explicit and explore differences that challenge integration of measures (e.g. scale and time horizon).”*

Who should act? EU and EU Member States, coastal managers and climate adaptation practitioners.

<sup>12</sup> More information: <https://ec.europa.eu/research/environment/index.cfm?pg=nbs>

solutions, including in their contribution to resilience and DRR. Priority 2 of the Sendai Framework (§28 (d)) points to the need for transboundary cooperation for the implementation of ecosystem-based approaches EBS for DRR e.g. in shared coastlines and river basins.

The Sendai Framework (§47(d)) recommends the incorporation of disaster risk reduction measures into a range of sectors and initiatives, including measures to adapt to climate change. This is also echoed by the EU Climate Adaptation Strategy (COM/2013/ 216) that recommends that Member States' adaptation plans are in synergy with existing disaster risk management policies. In the RISC-KIT project, although many DRR measures selected by end-users had an implicit adaptation component, this perspective was for the most part not explicit. Clearly indicating such commonalities between CCA and DRR measures can ensure approaches are synergistic rather than antagonistic. Efforts towards integrating DRR measures with adaptation actions should however take into account that there is a frequent mismatch of temporal and spatial scale between climate adaptation and DRR (EFDRR, 2013). For example, DRR measures may focus on addressing existing risks while adaptation strategies must take a long-term perspective.

## 5.6 Lessons learned on: Stakeholder involvement

The active engagement of stakeholders from eight different categories<sup>13</sup> was cultivated by the RISC-KIT project team from the outset. These stakeholders, not only experts but also ordinary citizens, played a central role both as providers and recipients of information on coastal risk and approaches to DRR. The importance of this type of engagement is also reflected in the Sendai Framework guiding principles (§19 (d)), which note that effective disaster risk reduction requires an 'all-of-society' engagement and partnership. This is also an important component of the implementation of the Floods Directive (§9) which aims for the 'active involvement of all interested parties'

RISC-KIT recommendation on stakeholder involvement (ii)

*"Ensure that local knowledge is recognised and valued as a complement to scientific knowledge to develop an integrated understanding of coastal risk and to devise locally appropriate DRR approaches and measures."*

Who should act? Policy makers at national and local level; academic community; consultants and research funding bodies.

RISC-KIT recommendation on stakeholder involvement (i)

*"Cultivate inclusive stakeholder processes to support 'all-of-society' approaches that are in line with the Sendai Framework and produce more effective DRR outcomes."*

Who should act? Policy makers and coastal managers at national, regional and municipal levels; academic community; consultants; research funding bodies.

<sup>13</sup> The eight stakeholder groups identified by the RISC-KIT project team were: Coastal manager; Land use planner; Civil protection/ disaster management agency; Academic; Consultant; Local resident; Chairperson of local groups; Local authority

Stakeholders were essential to the process of gathering data, particularly to the 150 in-depth interviews conducted in ten different case study sites. However, this was not only with ‘experts’ but also with ordinary citizens. In the RISC-KIT project, local residents are understood as gatekeepers of important historical and cultural knowledge, who often hold the key to understanding behaviours and attitudes in relation to coastal risk and DRR approaches and measures. Furthermore, where quantitative data was unavailable or inaccessible, stakeholders assisted by providing information that was not readily available in the public domain and/or expert knowledge. Our approach and findings are reflected in the Sendai Framework (§24 (i)) which highlights the need to use local knowledge to complement scientific knowledge to understand local systems and produce locally-appropriate strategies.

The RISC-KIT project also carried out substantial activities to engage with stakeholders and disseminate knowledge about coastal flood risk and DRR (See Chapter 3.5). In addition, stakeholder contact with the RISC-KIT tools had positive impacts on learning and awareness - in particular where disasters occur with less frequency, or where participatory processes are less developed (See Chapter 2.5.2).

These findings are in line with the Sendai Framework’s notion that civil society involvement supports general public awareness to grow a culture of prevention and education (Sendai Framework § 36). The Sendai Framework furthermore notes that an all-of-society approach includes encouraging civil society to collaborate with public institutions to provide them with specific knowledge and pragmatic guidance on DRR frameworks and plans (Sendai Framework §19 (g)). The Multi-criteria Analysis tool (See Chapter 2.5) proved to be an excellent tool for providing exactly this kind of knowledge and guidance; with representatives of local groups able to directly discuss with local government about the ‘real world’ implications of particular DRR measures.

Taking an inclusive approach to engage a wide range of stakeholders was of particular importance to the RISC-KIT project and special efforts were made to attain gender balance in outreach activities (See Chapter 3.5). Furthermore, the nature of the problems we deal with in DRR and the long-term analyses we work with, demands involvement of different generations. This was clearly reflected in some of the stakeholders’ perceptions of longer-term scenarios. Stakeholders of an older age felt that “some things need to be left for the next generations because we cannot care

RISC-KIT recommendation on stakeholder involvement (iii)

*“Make use of participatory tools (e.g. the RISC-KIT Multi-criteria Analysis tool) to disseminate information and engage with citizens and stakeholder groups who provide important ‘reality checks’ to planned DRR measures.”*

Who should act? Local policymakers and coastal managers, consultants.

RISC-KIT recommendation on stakeholder involvement (iv)

*“Stakeholder engagement processes must be fully inclusive should promote women and youth participation and leadership.”*

Who should act? Policy makers and coastal managers at national, regional and municipal levels; academic community, consultants; research funding bodies.

about everything" (Barquet and Cumiskey, 2017). Thus, achieving greater gender and age representation at all levels is crucial for diversifying the issues that are being included in DRR agendas and which of these get prioritised. Stakeholders who participated in the local Multi-criteria Analysis workshops were primarily of an older generation (84%) and there was a gender imbalance (68% male: 32 % female). These figures underline the relevance of pursuing the goal of the Sendai Framework (§19 (d)) to promote women and youth participation and leadership.

## 5.7 Lessons learned on: Dissemination

RISC-KIT took a multi-avenue approach to dissemination, which worked very well in the context of this project. The consortium took advantage of online and social media tools; the popular media including newspapers, radio and television; public fora; dedicated scientific and technical conferences; academic journals; and other international networking events such as European Maritime Day, to inform the public, stakeholders and end users about the project and its products.

The Sendai Framework recognises the need to disseminate disaster risk information, not only to decision makers but to the general public and communities at risk of exposure to disaster in an appropriate format (§24 (c)) towards empowerment and inclusive, accessible and non discriminatory participation (§19 (d)).

RISC-KIT has paid particular attention to adapt the language and format of the message to each of the target audiences in question. At times, this meant using simple language and appealing imagery such as in the RISC-KIT animated film, at other times it involved using sophisticated and technical language, such as presenting the project tools at academic conferences. Broader communication methods, such as the periodically produced RISC-KIT e-newsletter were very well received by a general audience, however, in terms of engagement, the personal connections developed and cultivated between team members responsible for the case studies and regional actors were perhaps the most valuable to the development of the project and the potential update of the project outputs.

### RISC-KIT recommendation on dissemination

*"Tailor research outputs to your audience: create products that are accessible and understandable for at-risk communities in the broader public as well as creating products that provide the necessary detail to decision-makers and academics."*

Who should act? Academic community; consultants.

## 6 Further information

Coastal Vulnerability Indicator Library	<a href="http://www.risckit.eu/np4/file/23/RISC_KIT_D.2.2_CVI_Library1.xlsx">http://www.risckit.eu/np4/file/23/RISC_KIT_D.2.2_CVI_Library1.xlsx</a>
XBeach	<a href="http://xbeach.org">http://xbeach.org</a>
CRAF2 setup scripts	<a href="http://www.risckit.eu/np4/file/383/CRAF2_scripts_Delft.rar">http://www.risckit.eu/np4/file/383/CRAF2_scripts_Delft.rar</a>
LISFLOOD	<a href="http://www.bristol.ac.uk/geography/research/hydrology/models/lisflood/">http://www.bristol.ac.uk/geography/research/hydrology/models/lisflood/</a>
INDRA model	<a href="http://www.risckit.eu/np4/file/23/INDRA.zip">http://www.risckit.eu/np4/file/23/INDRA.zip</a>
Delft Dashboard	<a href="https://publicwiki.deltares.nl/display/OET/DelftDashboard">https://publicwiki.deltares.nl/display/OET/DelftDashboard</a>
	( <a href="https://publicwiki.deltares.nl/display/RISCKITPUBLIC/RISC-KIT+Coastal+Documentation">https://publicwiki.deltares.nl/display/RISCKITPUBLIC/RISC-KIT+Coastal+Documentation</a> ).
Guidance and examples for a MCA session	<a href="http://www.risckit.eu/np4/file/386/RISCKIT_D.4.2_MCA_Guide_2016.pdf">http://www.risckit.eu/np4/file/386/RISCKIT_D.4.2_MCA_Guide_2016.pdf</a>
Web-based management guide	<a href="http://coastal-management.eu">http://coastal-management.eu</a>
Demo Bayesian Decision Support System	<a href="http://www.risckit.eu/np4/file/384/demonstration_DSS.zip">http://www.risckit.eu/np4/file/384/demonstration_DSS.zip</a>
Bayesian Network Adapter and Instructions	<a href="https://publicwiki.deltares.nl/display/FEWSDOC/Bayesian+Network+Adaptor">https://publicwiki.deltares.nl/display/FEWSDOC/Bayesian+Network+Adaptor</a>
GeNie	<a href="http://www.bayesfusion.com/">http://www.bayesfusion.com/</a>
Delft-FEWS Coastal	<a href="http://www.risckit.eu/np4/file/384/Coastal_FEWS_infrastructure__master_con.zip">http://www.risckit.eu/np4/file/384/Coastal_FEWS_infrastructure__master_con.zip</a>
Model adapters FEWS	<a href="https://publicwiki.deltares.nl/display/FEWSDOC/Models+linked+to+Delft-Fews">https://publicwiki.deltares.nl/display/FEWSDOC/Models+linked+to+Delft-Fews</a>
Web-based Viewer	<a href="http://al-ng017.xtr.deltares.nl/risckit/index.htm">http://al-ng017.xtr.deltares.nl/risckit/index.htm</a>

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**PRESENTATIONS AND DOCUMENTATION**

<i>Name</i>	<i>Document</i>
	<a href="http://www.risckit.eu/np4/file/23/RISC_KIT_D.2.2_CVIL_Guidance_Document.pdf">http://www.risckit.eu/np4/file/23/RISC_KIT_D.2.2_CVIL_Guidance_Document.pdf</a>
	<a href="http://www.risckit.eu/np4/file/23/RISC_KIT_D2.3_CRAF_Guidance.pdf">http://www.risckit.eu/np4/file/23/RISC_KIT_D2.3_CRAF_Guidance.pdf</a>
	<a href="http://www.risckit.eu/np4/file/382/RISC_KIT_D1.3_Tools_webpage.pdf">http://www.risckit.eu/np4/file/382/RISC_KIT_D1.3_Tools_webpage.pdf</a>
	<a href="http://www.risckit.eu/np4/file/383/step1_intro_CRAF2_Hazards_DDB.pdf">http://www.risckit.eu/np4/file/383/step1_intro_CRAF2_Hazards_DDB.pdf</a>
	<a href="http://www.risckit.eu/np4/file/383/step2_CRAF2_modelling_steps.pdf">http://www.risckit.eu/np4/file/383/step2_CRAF2_modelling_steps.pdf</a>
	<a href="http://www.risckit.eu/np4/file/383/INDRA_WorshopFaro1904_vf.pdf">http://www.risckit.eu/np4/file/383/INDRA_WorshopFaro1904_vf.pdf</a>
	<a href="http://www.risckit.eu/np4/file/385/RISC_KIT_PPT_Mgmt_Guide_ECSA.pdf">http://www.risckit.eu/np4/file/385/RISC_KIT_PPT_Mgmt_Guide_ECSA.pdf</a>
	<a href="http://www.risckit.eu/np4/file/384/RISC_KIT_EA_Day_hotspot_tool.pdf">http://www.risckit.eu/np4/file/384/RISC_KIT_EA_Day_hotspot_tool.pdf</a>
	<a href="http://www.risckit.eu/np4/file/384/AB_19_22_FINAL_PAPER_Development_of_Gene.pdf">http://www.risckit.eu/np4/file/384/AB_19_22_FINAL_PAPER_Development_of_Gene.pdf</a>
	<a href="http://www.risckit.eu/np4/file/384/Howto_Webviewer.pdf">http://www.risckit.eu/np4/file/384/Howto_Webviewer.pdf</a>
	<a href="http://www.risckit.eu/np4/file/384/Bayesian_workshop.pdf">http://www.risckit.eu/np4/file/384/Bayesian_workshop.pdf</a>
	<a href="http://www.risckit.eu/np4/file/386/MCA_Guide.pdf">http://www.risckit.eu/np4/file/386/MCA_Guide.pdf</a>



## 7 References

- Barquet, K., Dickin, S., Meijer, J.J., Dastgheib, A. (2017 forthcoming). *Piloting RISC-KIT's integrated approach for assessing Disaster Risk Reduction measures in the coast of Kristianstad, Sweden*. Coastal Engineering.
- Barquet, K., and Cumiskey, L., et al. (2017). *Evaluation of Disaster Risk Reduction plans. Resilience-Increasing Strategies for Coasts – toolKIT (RISC-KIT)*
- Bogaard, T., De Kleermaeker, S., Jäger, W.S. (2017 forthcoming). *Development of Generic Tools for Coastal Forecasting and Warning*. Coastal Engineering.
- Checkland P. and Poulter J. (2006). *Learning for Action: a Short Definitive Account of Soft Systems Methodology and its Use for Practicioners, Teachers and Students*. Chichester, Wiley.
- Ciavola, P., Harley, M.D., den Heijer, C. (2017 forthcoming). *The RISC-KIT storm impact database: a new tool in support of DRR*. Coastal Engineering.
- COM (2014) *Technology readiness levels (TRL)*. HORIZON 2020 – WORK PROGRAMME 2014-2015, General Annexes, Extract from Part 19 - Commission Decision C(2014)4995.
- European Commission. (2013). *Guidance for Reporting under the Floods Directive (2007/60/EC)*. Brussels.
- European Forum for Disaster Risk Reduction (EFDRR) (2013): *How does Europe link DRR and CCA- Working Paper*.
- Garnier, E., Ciavola, P., Spencer, T., Ferreira, O., Armaroli, C., McIvor, A. (2017 forthcoming). *Historical analysis of storm events: case studies in France, England, Portugal and Ital*. Coastal Engineering.
- Martinez, G., Armaroli, C., Costas, S., Harley, M.D., Paolisso, M. (2017 forthcoming). *Experiences and results from interdisciplinary collaboration: Utilizing qualitative information to formulate 3 disaster risk reduction measures for coastal regions*. Coastal Engineering.
- ISDR - International Strategy for Disaster Reduction (2007) *HYOGO FRAMEWORK FOR ACTION* – ([http://www.unisdr.org/files/1037\\_hyogoframeworkforactionenglish.pdf](http://www.unisdr.org/files/1037_hyogoframeworkforactionenglish.pdf))
- Plomaritis, T., Costas, S., Ferreira, O. (2017 forthcoming). *Use of a Bayesian Network for coastal hazards, impact and disaster risk reduction assessment at a coastal barrier (Ria Formosa, Portugal)*. Coastal Engineering.
- Van Dongeren, A., Ciavola, P., Martinez, G., Viavattenne, C., Bogaard, T., Ferreira, O., Higgins, R., McCall, R. (2017 forthcoming). *Introduction to RISC-KIT: Resilience-increasing strategies for coasts*. Coastal Engineering.